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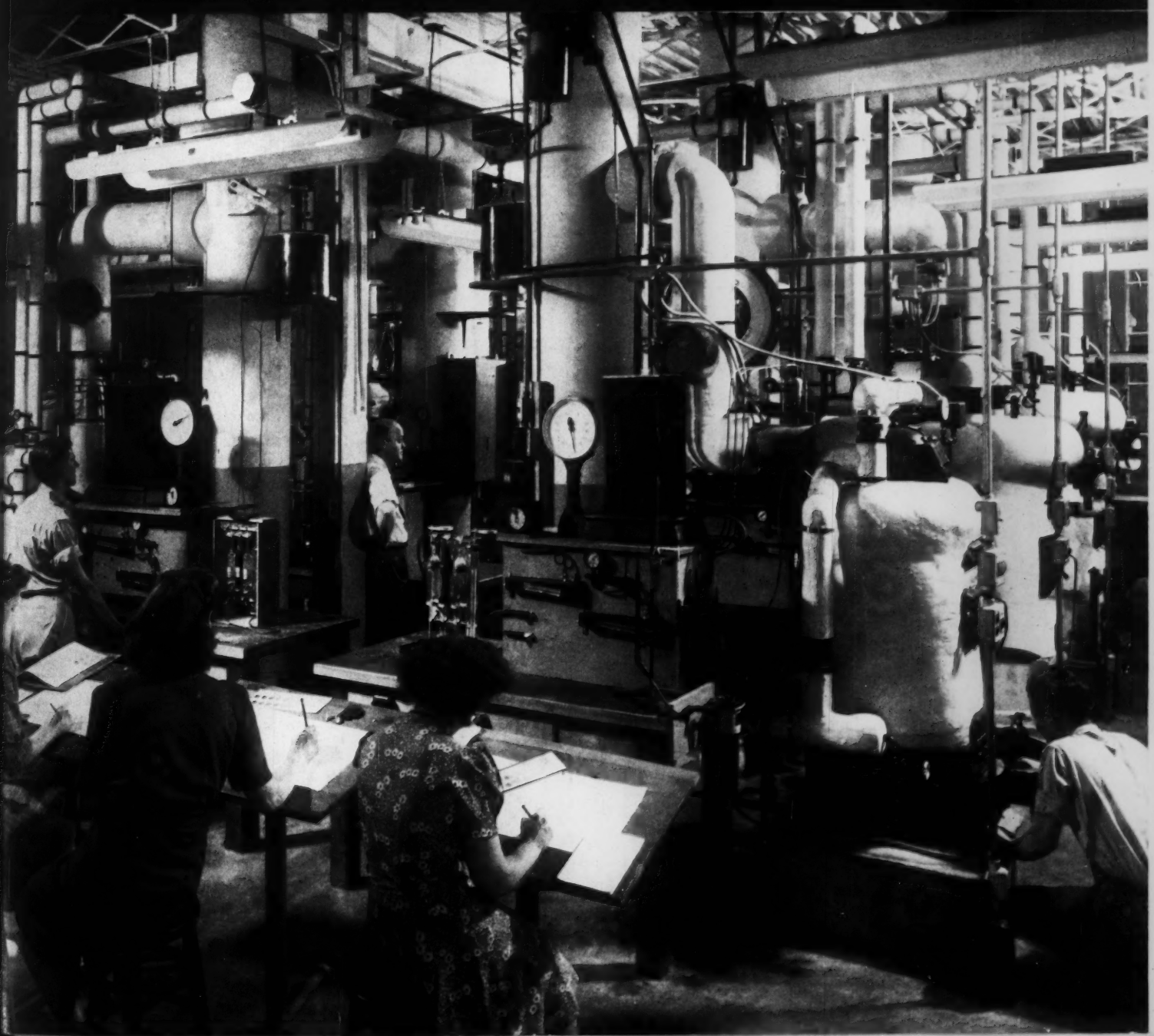
Instruments

THE MAGAZINE OF Measurement and Control



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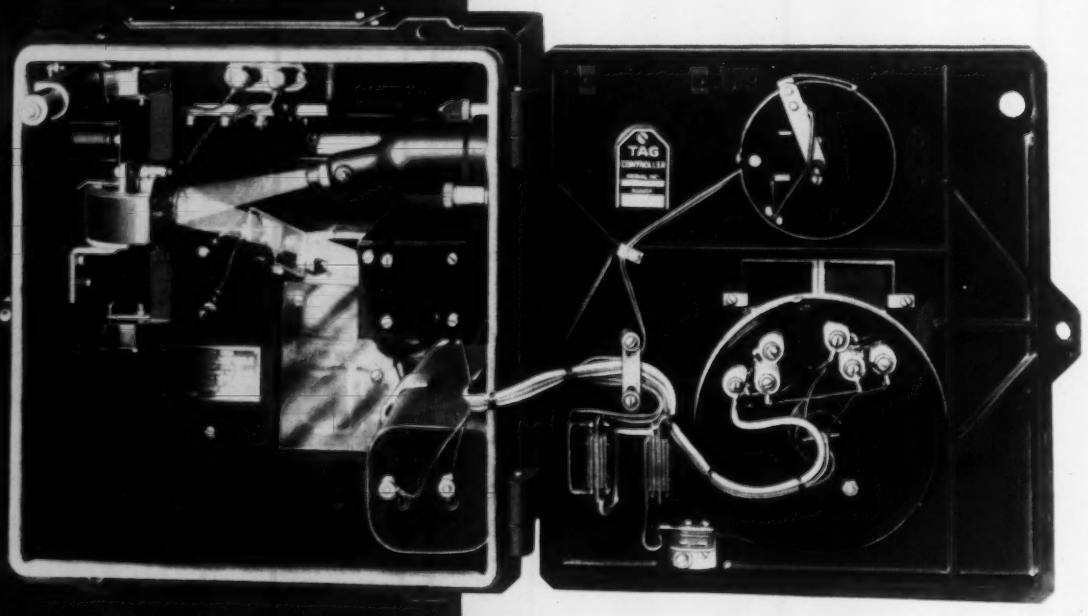

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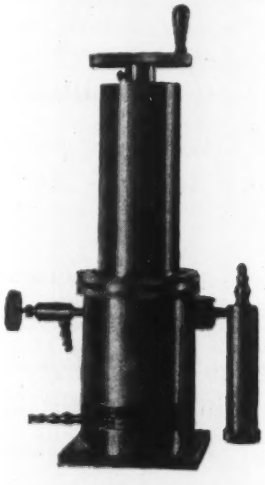

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Instruments
THE MAGAZINE OF Measurement and Control

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EDITORIAL By M. F. BEHAR

Can "Accuracy" Be Defined?

IN one of the conversations with old subscribers whom we met for the first time at the ISA Conference (and what a pleasure it was to meet them!) our friend commented shrewdly on the publicizing of new instruments:

"When I have to spend the company's money on a valve for a six-inch line, I don't order a two-inch valve or a twenty-inch valve. That's why, when I have to order instruments, meters and controllers, I always look for facts and figures. That's why I pay no attention to such wordings as 'ultrasensitive' or 'very accurate' or 'absolutely shockproof,' if the announcements do not back them up with facts and figures such as the percent accuracy. One reason why I like your magazine is because your new-product columns are so full of facts and figures and so free from ballyhoo. Is it true that instrument companies usually state the percent accuracy of their new products in announcements they send you and not in those they send to other periodicals?"

"Not usually," we explained. "Most manufacturers send the same announcements and pictures to all technical magazines. What we do is to edit all, re-write some and, yes, sometimes we request the figures our readers look for when these have been left out—especially the percent accuracy."

"Is it true, then, that some manufacturers instruct their sales engineers to refuse to give any percent accuracy guarantees? That's what one sales engineer did and although I like him I think his company is too conservative."

"There are many cases," we replied, "when a company cannot guarantee that the instrument will be as accurate when you have installed it as it was in the factory."

"Oh, I know all about that," our friend exclaimed, "and my kick is that this man wouldn't even give me the factory accuracy figures on this new flowmeter. I want to know HOW accurate it is under correct conditions because I intend to have the installation conditions absolutely correct."

"Did you say a flowmeter?" we asked.

"Yes, an orifice meter, electric type."

We promptly informed our friend that we never request manufacturers of electric flowmeters to include the percent accuracy in their announcements of new models.

By coincidence, the question of accuracy had been raised the preceding evening at a technical committee meeting: an engineering official of a company which manufactures electric flowmeters had reported that awkward situations sometimes arise when prospective customers desire written accuracy guarantees. He wanted a definition of "accuracy," applicable to these situations, to be made available.

Such a definition was made available in 1932. However, it represented the result of an attempt to deal with the accuracy of indicators, of recorders and of integrators, to combine the utmost rigor, explicitness and clarity. This result "had everything" . . . except brevity; it ran to twenty-four pages full of "ifs" and "buts." The following lacks some touches of a Standard but it is readable and serviceable:

Axiom I. There is no such thing as absolute accuracy in the instrumental measurement of variable magnitudes such as flow-rate, temperature, speed, pressure, pH, etc.

Axiom II. The function of a measuring instrument is to assign to a measured magnitude a numerical value, i.e., a mathematically-usable quantity.

It follows that "accuracy" is the relation between the true value (of the magnitude) and the obtained value (of the quantity). In other words, when all of us say "accuracy," what we have in mind is INaccuracy.

The true value, of course, is a quantity obtained by means of a "more accurate" instrument which has been certified by means of "still more accurate" instruments. Or it may be a fixed point of Nature, such as the temperature of equilibrium between ice and air-saturated water at normal atmospheric pressure.

This definition is unassailable, but as a specification it applies to the accuracy of an instrument at only one point on its full scale—to the Point Accuracy. The important property known as INTRINSIC Accuracy is defined as the extent or closeness to which the readings (note the plural) of the instrument approach the true values. The adjective "intrinsic" is necessarily used here to denote the accuracy of which the instrument is capable, not its variable accuracy under unpredictable service conditions. The expression "intrinsic accuracy" should be used, therefore, in preference to unqualified "accuracy" in the wording of users' specifications and makers' guarantees.

Intrinsic accuracy should be explicitly stated in terms of the **Limit of Error,** "the maximum error by which the readings (note the plural) of an instrument will depart from true values."

The limit of error, in turn, may be expressed in different ways:

1. Its value at a given point, or in a given region of the scale. (Useful in the case of some tachometers and thermometers, instruments having square-root-law primary elements, etc.)
2. Its ratio to the true value above absolute zero. (Useful for suppressed-scale instruments.)
3. Its percent of the scale range. (Preferanble for most instruments with uniformly-graduated scales.)

The intrinsic accuracy of a measuring instrument usually is the resultant of its specific measuring properties, such as Degree of Precision, Unit Sensitivity, Speed of Response, Scale Law, Readability, Variance, Figure of Merit, Barometric Coefficient, Temperature Coefficient, Position Error, etc. These should be kept in mind. For example, consideration of Speed of Response suggests a distinction between STATIC and DYNAMIC Accuracy—the latter sometimes expressed not in words but in graphs.

* * *

The foregoing suffices for most measuring instruments, but not for many multi-stage or complex measuring systems such as electric flowmeters, because the user may have in mind the OVER-ALL intrinsic accuracy of the totality of the parts he buys, while the seller knows from experience that each component may become the source (not the "cause" but, say, the "locus") of relatively large errors—unpredictable in new industries, new processes, etc.

We were asked how we, representing users, would word the accuracy specification for an electric flowmeter; or how we would state the accuracy guarantee if we were the flowmeter manufacturer. The request was unofficial; our reply is not in the language of specifications. We would speak as follows to a friend:

"First, the orifice plate. Its orifice diameter is 4.735" $\pm$0.001"; its orifice roundness is true to $\pm$0.001" and we therefore guarantee its DIMENSIONAL limit of error to be $\pm$0.02%, or $\pm$0.04% in terms of AREA—not in your vapor line but at room temperature. The coefficient of linear expansion of the alloy is 10.6×10^{-6} per degree C. at room temperature and 13.7×10^{-6} at 400°C. so that you can compute for yourself the effect on the orifice coefficient at your working temperature. What's that? You want me to guarantee the accuracy of the orifice coefficient at 375°C. without knowing the pipe I.D. and other data? Not on your life!

"Now let's go to the other end—at the control board. Our recorder, *as an electrical recording instrument*, has a limit of error of 0.6%. Yes, in a Canadian winter or an Iranian summer, because it is temperature-compensated, but don't forget that paper charts—even ours—are hygroscopic, so that in a moist location the humidity error may be 2% of the chart's scale range.

"Our manometer has a limit of error of $\pm$0.5% when correctly installed, leveled, etc. This figure refers specifically to its *functional* intrinsic accuracy, in converting changes of differential pressure into electrical changes. Owing to square-root-extraction geometry, $\pm$0.5% applies only to the upper half of the range.

"Each of the two sealing chambers or reservoirs has a negligible *dimensional* limit of error, say $\pm$0.01%. Call the errors additive and you get $\pm$0.02%. The functional limit of error, including capillarity, temperature and other effects, seldom exceeds $\pm$0.6% in factory tests. For field conditions, however, absence of errors—*enormous* errors—depends on your men. No guarantee!

"No guarantee either for absence of large errors originating in the pressure connections and lines, or in that mile-long electric cable your men will install between our manometer and our recording instrument. And *now that you understand our reservations*, I can guarantee that the over-all intrinsic accuracy of the components we offer you is $\pm$1.5% for the upper half of the range and—of course—for the fairly steady flows we have reason to expect in a continuous chemical process.

"What's that? Wildly fluctuating flow? Reciprocating pumps? Why, my dear Mr. User, I wouldn't give a flow-measurement guarantee to a department in our own factory with our own men making the installation, if the flow fluctuated!"

Conclusion: Remember "intrinsic" and "functional" in particular and, in general, whenever you strive for utmost clarity in requesting or giving information, qualify the noun "accuracy" by whatever adjective or phrases are applicable, such as "at room temperature," "electrical," "dimensional," "on a shock-insulated panel," etc. —MFB

ORGANIZATION of the Instrument Division at Canada's SYNTHETIC RUBBER PLANT

By J. W. GRAEB, Polymer Corp. Ltd., Sarnia, Ontario.

Introduction

BORN of a wartime emergency, Canada's Synthetic Rubber Plant grew from a mosquito-ridden forest to a complete rubber-producing plant in twenty months. The acute rubber shortage affected Canada no less than the United States and the synthetic rubber program of the two countries was integrated, resulting in complete interchange of ideas in the design, construction, and operation of the synthetic rubber producing units. Canada's share in the program was such that it was considered advisable to build one large plant, complete and self-contained, which would produce both Buna-S and Butyl Rubbers from the light hydrocarbon raw materials.

The Government of Canada set up a Crown Company, Polymer Corporation Limited, to build and operate the plant, and to handle all matters pertaining to synthetic and natural rubber in Canada. Three operating companies were formed under Polymer Corporation, to manage the actual operation of the various process units on a management-fee basis.

Dow Chemical Company of Canada operates the three units of the styrene plant—the ethylbenzene unit, the styrene cracking unit, and the styrene finishing unit.

Canadian Synthetic Rubber Company operates the co-polymer plant where styrene and butadiene are combined to form Buna-S rubber.

St. Clair Processing Corporation was formed to operate the Light Ends Recovery Unit, Isobutylene Extraction Unit, Butyl Rubber Unit, Butylene Concentration Unit, Butadiene Dehydrogenation Unit, Butadiene Extraction Unit, Steam and Power Plant, Central Mechanical Shops, and General Storehouse. In May of this year St. Clair Processing Corporation was absorbed into Polymer Corporation which now operates directly all the areas formerly operated by St. Clair Processing Corporation.

In this paper it is proposed to deal only with the Instrument Division as operated formerly by St. Clair Processing and now by Polymer Corporation. Both Dow Chemical and Canadian Synthetic Rubber have their own well-equipped and well-organized Instrument Departments which they operate themselves. In referring to the "Polymer Instrument Division," it is understood that only that Instrument group operated directly by Polymer Corporation is meant.

Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept. 16-20, 1946.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

Internal Organization

The Instrument Division is headed up by an Instrument Engineer and an Assistant Instrument Engineer who divide the responsibility of the group between them. Under these men are five groups of mechanics, each supervised by an Instrument Foreman.

For operating supervision the plant is divided into three main sections: The Feed Preparation Section, consisting of the light ends recovery, isobutylene extraction, butylene concentration and butane blending units; the Butadiene Section consisting of two identical butadiene dehydrogenation units and the butadiene extraction unit; and the Butyl Rubber Section consisting of the fractionation, polymerization and finishing sections of the butyl unit. Each of these three sections has its own Instrument Foreman and group of Instrument Mechanics. A fourth group looks after the steam and power plant instrumentation, and the utility and accounting meters throughout the plant. The fifth group is the Instrument Shop crew, a special group which will be dealt with later.

The responsibilities of the Instrument Engineer and his Assistant include the formulation of over-all policy, coördination among the groups, personnel problems, technical problems, specification of new equipment, standardization of installation and maintenance, and conducting instrument training programs. In general the Assistant Instrument Engineer is responsible for technical problems and the training program, and the Instrument Engineer handles personnel problems and the specification and standardization work. The division of responsibility is not sharply defined, and each is kept sufficiently informed of the other's work that the duties of both may readily be assumed by either one.

As far as possible the instrument foremen are given a free hand in the supervision of their men and in the operation and maintenance of the equipment for which they are responsible.

The organization of each of the various groups differs somewhat, depending on the exact nature of their duties and problems, but the three groups working directly on the process units may be considered as identical. Under the foreman is one First Class Instrument Mechanic who is designated as Senior Mechanic for that group, four shift mechanics who are classed as First, Second, or Third Class mechanics depending on their skill and experience, and two additional mechanics who may be any grade from Junior Mechanic, which is one grade below Third Class, to First Class, depending on the status of the training program and the necessities of that particular unit.

The shift men are the key men of the organization. They are trained and expected to handle all instrument problems that arise during their shift and little work is left over from shift to shift for the day crew to do. The processes being controlled are of such a nature that the operating departments do not care to operate on manual control any more than absolutely necessary, and all instrument troubles are taken care of at the time they occur. The only work that the shift men are allowed to pass over to the next shift is what they could not finish for lack of time, or work which required the assistance of a shop specialist. It is felt the job of shift mechanic actually requires a First Class Instrument Mechanic and it is expected that all the shift jobs will eventually be filled by First Class Mechanics. The rest of the men in the unit crews work on routine inspections and overhauls, small installation jobs, and special work brought about by new developments suggested by the Technical, Process, or Instrument groups.

It should be explained at this point that the grading of the mechanics is from Handyman, which is the starting grade, progressively through Helper, Junior Mechanic, Third Class, Second Class to First Class Mechanic.

The Power Plant and Utility group consists of two mechanics who are either First or Second Class and two Helpers in the power plant, two Junior Mechanics and two Handymen on the utility meters.

While the Steam and Power Plant is completely equipped with modern instrumentation and control throughout, the maintenance problems are not of a nature requiring a mechanic to be

present at all times, and it is not necessary to have shift men on hand.

The problem of accurately measuring feed stocks, products, and utilities such as steam, water, fuel gas, and compressed air throughout the plant, is a major one. Accordingly four men, as designated above, are kept busy looking after the maintenance of the meters on these services. As the work is mainly of a routine nature, dealing mostly with flowmeters and pressure recorders, and does not require work on control or transmission systems, less experienced mechanics are entrusted with this work.

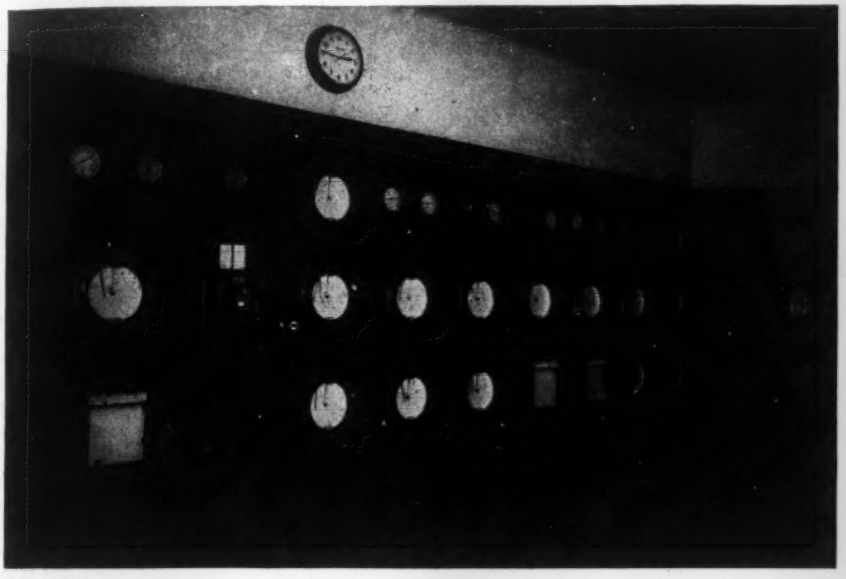


Fig. 1. Control Panel—A partial view of the control panel for the Light Ends Recovery Unit.

Shop Organization

The Instrument Shop crew is organized to combine flexibility with specialization to as great an extent as possible. Each of the five First Class Mechanics in the shop has his own specialty, such as Machinist, Electrician, Valve Mechanic, Watchmaker, and Pipefitter, but each is familiar with other, more general, phases of instrument work so that he may fill in elsewhere if needed.

In general the Machinist handles all lathe and machine work, rebuilding mechanical instruments, and constructing new or experimental devices. The Electrician handles the complete overhaul and rebuilding of electrical and electronic instruments such as potentiometers, resistance thermometers, pH instruments, gas analyzers of several descriptions, electrical time-cycle controllers, etc. The Valve Mechanic handles complete valve overhauling and rebuilding, welding jobs not requiring the services of a fully qualified welder, displacement meter overhauls, work on self-acting pressure and temperature regulators, and instrument overhauls. The position of Watchmaker is filled by a fully qualified Watchmaker who repairs all pressure gages, chart drives both mechanical and electrical, laboratory stop watches, laboratory balances, and the plant master clock in the Power Plant. In addition he undertakes all extremely fine machine work. The Pipefitter handles all installation work except on jobs which are too large or too urgent to be handled by one man and his helper. This includes mounting and connecting instruments to the process lines or vessels, and running copper tubing lines to and from instruments and valves. This man also does general instrument overhaul.

The shop crew has three additional men—a Third Class Mechanic who acts as Electrician's helper and two men who may be any grade from Handyman to Junior Mechanic. These men are in the shop for training purposes and work wherever needed.

As mentioned above flexibility is one of the main features of the shop organization, and this feature is well maintained in spite of, or perhaps because of, our shop specialization. The shop works very closely with the unit groups and in times of extra work as occasioned by unit turnarounds or by some emergency, members of the shop crew assist on the units and also handle work in the shop normally done by the unit crews.

With the present organization and coverage of the work the instrument division in general, and the instrument shop in particular can handle almost any job connected with instruments; about the only jobs "farmed out" are heavy machine and pipe-fitting jobs, some welding jobs, and some electrical installation jobs. In fact the trend is rather in the other direction, with the instrument division being asked to do a great deal of fine work not normally connected with instrumentation.

External Relationship

One of the most noteworthy features of the Instrument Division is its location in the organization chart, and its relationship to other groups and departments within the organization.

The Instrument Division is not connected in any way with either the Mechanical or Engineering Departments but is one of the sections of the Production Control Department, with the Instrument Engineer reporting directly to the Technical Superintendent. The other sections of the Production Control Department are two Technical Groups, each headed by a Production Controller, and a Yield Section, headed by a Yield Controller.

The Instrument Division was not made part of the Engineering or Mechanical Departments because, apart from purely routine maintenance work, the problems encountered in instrument work are very closely connected with the technical and operating aspects of the process. So often, in tracking down "Instrument trouble" the trouble will be, partly at least, in the process rather than in the instrument, and a knowledge of the process is almost as important to the instrument mechanic as a knowledge of the mechanical features of the instruments themselves.

To facilitate the close coöperation among process, technical, and instrument groups so necessary to satisfactory instrumentation, the Instrument Division was made part of the technical or Production Control Department. Very close contact is maintained by the Instrument Engineers and Foremen with the other two groups mentioned above, and the offices of all three are located in the same building close to the geographical center of the plant.

Maintenance Routine

To as great an extent as possible, all maintenance is put on a routine basis. The emphasis is on "Preventive Maintenance" rather than on repair work after an instrument or valve has failed in service.

Before being installed, new instruments are first brought in to the shop for inspection, calibration and testing. All instruments in the plant are given a complete overhaul and inspection at intervals of six months to a year, depending on the severity or importance of the service, and the accessibility of the instrument. Instruments which cannot be taken out of service while the units are operating are overhauled on the regular shut-downs for inspection of and mechanical repair to the units.

Orifice plates and orifice nipples are inspected at intervals of once a year or oftener, again depending on importance, service, and accessibility. Orifice plates are re-machined or replaced if they show any signs of rounded edges, wire-drawing or nicks. Orifice nipples and pressure instrument nipples are replaced at least every two years to prevent fatigue or corrosion failure.

Pressure gages and chart drives come in to the shop regularly for inspection and calibration. With a few unavoidable exceptions, all pressure gages in the plant are calibrated about twice a year.

Control valves are also subject to a system of routine inspection and maintenance which includes regrinding plugs and seats and replacing the packing. All valve packings and lubricants are standardized for various services, and the valves are lubricated on a regular schedule.

A great deal of this maintenance work, with the exception of pressure-gage and chart-drive inspection, is carried on as part of the regular duties of the unit crews, with the shop handling overflow work in rush periods and jobs which the unit crews are not equipped to handle. All the mechanics are familiar with the checking and repair of pressure gages and chart drives, but this work is handled more efficiently at a central location.

By close adherence to the principle of "Preventive Maintenance" the service factor of the instruments is kept at a very high value. Their accuracy as measuring, recording, or controlling devices is also kept to a high value, and on some units it is possible to keep the over-all unit balances within $\pm 0.75\%$.

Standardization

It will be appreciated that, because the plant was built during wartime, with the greatest possible speed, it was not possible to standardize on material or equipment. Many installations, particularly on control valves, were of a make-shift or sub-standard nature.

In the 2½ years since the plant was completed it has been possible to improve many of these installations and make an effort towards standardization. It is felt that the advantages to be gained by such a move are more uniform and better installations, ease of maintenance, reduction and simplification of spare parts carried, and better operation of the Instrument Division generally. However, standardization is not carried to the extreme where it prevents new methods, ideas, or equipment being adopted if there is an advantage to be gained.

As mentioned above, control valve packings are standardized according to their service; lubricants for control valves and pressure-tight bearings are similarly standardized.

Valves and pipe used in mounting and connecting instruments are selected according to a definite code.

Many control valves had been installed with so-called "Victory by-passes" containing a by-pass valve, a single block valve, and no drain valves. All have now been converted to our standard installation of two block valves, a by-pass valve, and a drain valve on each side of the control valve, between the control valve and corresponding block valve.

Much of the original instrument air tubing was copper-clad steel; the job of replacing this with copper tubing is nearly completed.

On each unit, all important indicating, recording or controlling instruments are mounted in a central control house which is the nerve center of the unit. Flow, liquid level and temperature (except potentiometer-type) instruments in the control house are all receiver units actuated by pneumatic transmission from corresponding transmitter units scattered throughout the plant. Some pressure instruments mounted on the control room panels are directly connected to pressure vessels or process lines, but a program is under way to have these lines removed from the control houses and the installations replaced by transmitter-receiver systems. This is as much a safety matter as anything else, as the trend is to keep all lines containing inflammable hydrocarbons out of the control houses.

Some of our standards are set higher than necessary for many installations, but any extra cost incurred is more than offset by the flexibility achieved, reduction of spare parts carried, and improved operation. Orifice plates are all of stainless steel plate unless the line fluid is too corrosive. Control valves are carbon steel body with a 600-lb. rating and stainless steel trim. Orifice flanges are either carbon or stainless steel, one grade heavier than line flanges on the same service, and no ratings less than 300-lb. series 30 are used. Thermocouples are made in our own shop of selected, matched wire, and standardized to within $\pm 2°F.$ against a Bureau of Standards platinum vs. platinum-rhodium couple. Many couples, especially on high-temperature service, are not used again if they are removed from the well for any reason.

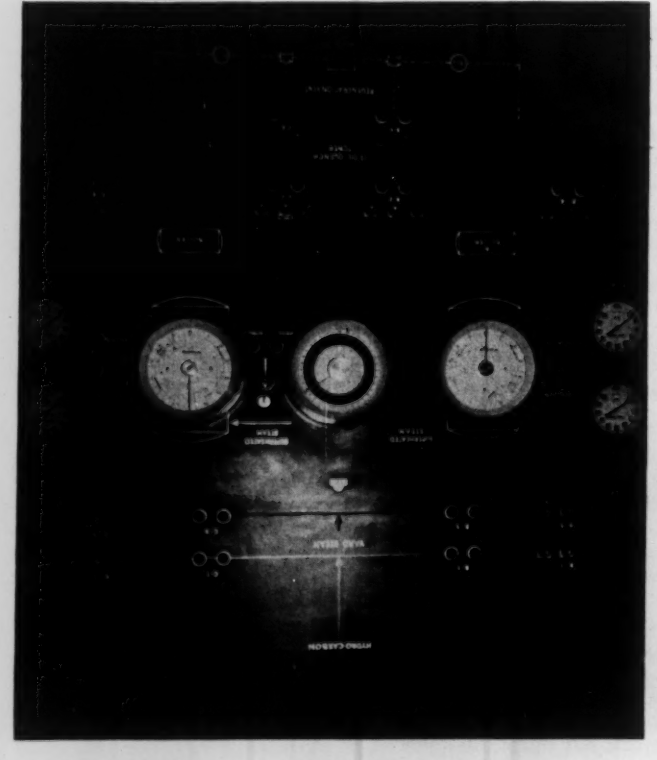


Fig. 2. Butadiene Dehydrogenation Unit Time-cycle Controller at Polymer Corp., Ltd.

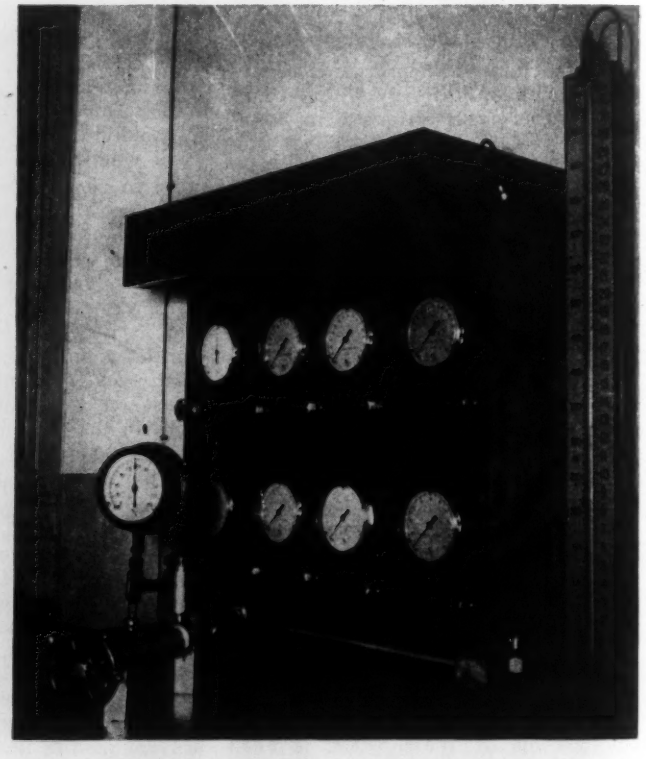


Fig. 3. Pressure Gage Test Bench, showing the pressure cylinder in foreground and the panel of laboratory test gages in background.

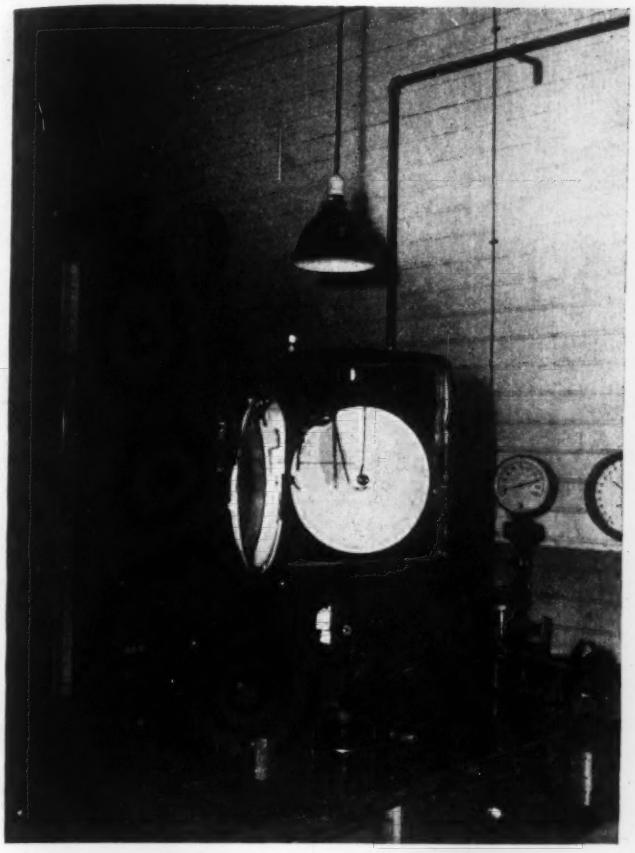


Fig. 4. Pressure Recorder Test Bench, showing the pressure cylinder and laboratory test gage to the right rear.

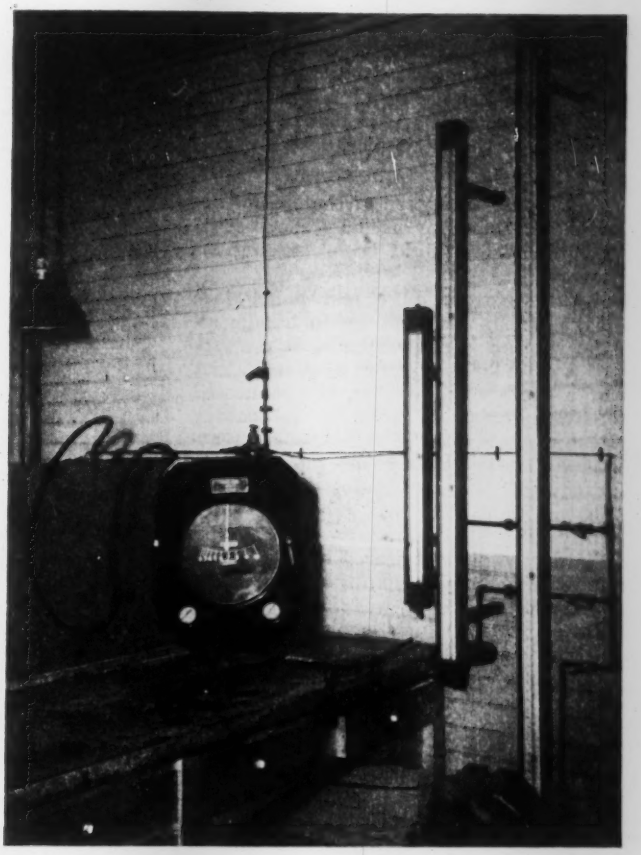


Fig. 5. Flowmeter Calibration Bench, showing the two air control valves in center foreground and manifolded manometers to rear.

Training Program

While the Synthetic Rubber Plant was being constructed, it was realized that a personnel training program was also necessary in order to have trained men to operate the plant. Imperial Oil Limited placed the facilities of their Sarnia refinery at the disposal of Polymer Corporation and undertook to train operating and instrument crews for the then St. Clair Processing Corporation. With the exception of only three or four of the key personnel, none of the men in the instrument training program had had any previous experience with instruments or automatic control. A truly remarkable training job was accomplished when it is realized that six to eight months after these men saw their first instruments they were putting complex process units into operation on completely automatic control under exceptionally adverse conditions with a minimum of delay.

The importance of having well-trained instrument mechanics can not be over-emphasized. The training program begun at Imperial Oil has been continued and in some respects enlarged.

New men entering the Instrument Division are examined critically with reference to their education and previous training and experience. Their education must include complete high school or technical school graduation. They start off in the shop where they are placed with one of the Senior Mechanics and given a chance to learn some of the fundamentals of instrument maintainence. At this time they are instructed mainly in the calibration and repair of pressure gages and flow meters; work on controllers, transmitters, potentiometers, etc., comes later. They are also given free access to the instrument division library which contains a fairly complete selection of instruction books, service manuals, and texts on instrumentation in theory and practice.

After an indefinite period, depending on the man's progress and changes farther along in the organization, he is moved to the Power Plant and Utility group as Handyman with the Utility Section. From there he proceeds by easy stages to Helper in the power plant, back to the shop for more advanced training, to one or more of the units as Junior Mechanic, to the Utility Meters as Junior Mechanic, and finally to one of the unit groups as a shift mechanic. It will be understood that this schedule is not rigidly followed in every case, but is set up rather as a guiding principle and is altered to suit existing conditions.

The shift men are not left on one unit indefinitely and allowed to get into a rut, but are moved from unit to unit and through the Steam and Power plant on a regular schedule. This serves to broaden their knowledge and experience as each unit has some features not found on any of the other units. It also makes the entire group more flexible in case of emergencies.

The theoretical side of instrumentation is also looked after by lecture periods held during the fall and winter months, at which the principles of measurement and control are explained. The nature of the various processes encountered in the plant are described in considerable detail, and the importance of a knowledge of the process as well as of the instruments is stressed.

Arrangements have been made with the local Collegiate to conduct night classes in physics, mechanics, chemistry, electricity and mathematics during the winter months, and the men are encouraged to attend these as refresher courses. During the past winter a course on elementary electronics, arranged by the Westinghouse Company and entitled "Electronics at Work" was given.

From time to time the foremen and senior mechanics are sent to the various training schools conducted by some of the instrument manufacturers. Senior men, rather than junior men, are sent to these schools as it is felt that they will be able to get more out of them and will be able to bring back more information for the general good.

A series of "Trade Tests" has been set up outlining what are believed to be the requirements of different grades of instrument mechanics, as applied to

the instrumentation problems in the plant. The tests range from Grade "D" which is the lowest through to Grade "A", which is the highest. These tests are not compulsory, but are recommended to the mechanics.

Special Equipment

It is felt that some of the special devices developed or used by the Instrument Division might be of passing interest.

The pressure gage test panel (see Fig. 3) has been set up to handle all the routine gage overhauls. It consists of a cylinder and piston similar to that of a dead weight tester, but connected to a manifolded series of laboratory test gages instead of to the weight platform. These gages cover the complete range of pressure gages encountered in the plant. The test gages are carefully calibrated at regular intervals by the dead weight tester. This system is faster and simpler than the dead weight test, and prevents wear on the dead weight tester, which is preserved as a primary standard.

A somewhat similar pressure testing device is shown in Fig. 4. The principle is the same, but this installation lends itself more readily to the calibration of pressure recorders.

One of the shop installations for the calibration of differential instruments is shown in Fig. 5. Three manometers are manifolded together with the meter under test and connected through two specially-constructed valves to a supply of compressed air. One of these is a three-way valve which allows the air to build up or bleed out as required. The second valve controls the rate of air flow, and may be adjusted so finely that there is no overshoot or "bounce" whatever in the manometer fluid. This is invaluable in checking for hysteresis.

Part of the electrical section is shown in Fig. 6. In the foreground a cathode-ray oscillograph is being used to adjust the converter of an electronic amplifier unit. An electrical test panel can be seen in the background; this consists of (from top to bottom) a tube checker, emission type, a volt-ohm-milliameter, a free point checker and switches to connect the jacks into appropriate test circuits.

One of the features of the newer part of the instrument shop is the use of individual work benches set at right angles to the wall, rather than long benches running along the walls. More work space is available, and different jobs are segregated.

On the most critical flow measurements a system of dual orifices and dual meters has been installed. The installations have been made to the most critical A.S.M.E. and A.G.A. specifications, with the second orifice placed one hundred pipe diameters downstream of the first. The whole installation is so manifolded that either orifice may be removed for examination without shutting off the flow through the other one. If the flow through the line varies widely two, or even three, meters may be manifolded into each orifice; these meters will have different range tubes so that there is always a duplicate flow record between 5 and 8 on a square-root chart. By strict attention to proper installation and maintenance, it is possible to make the meters on any given line agree among themselves to within 0.2%. Any disagreement of greater than 1% in either direction is cause for concern and the reason for the disagreement is found and steps taken to correct it.

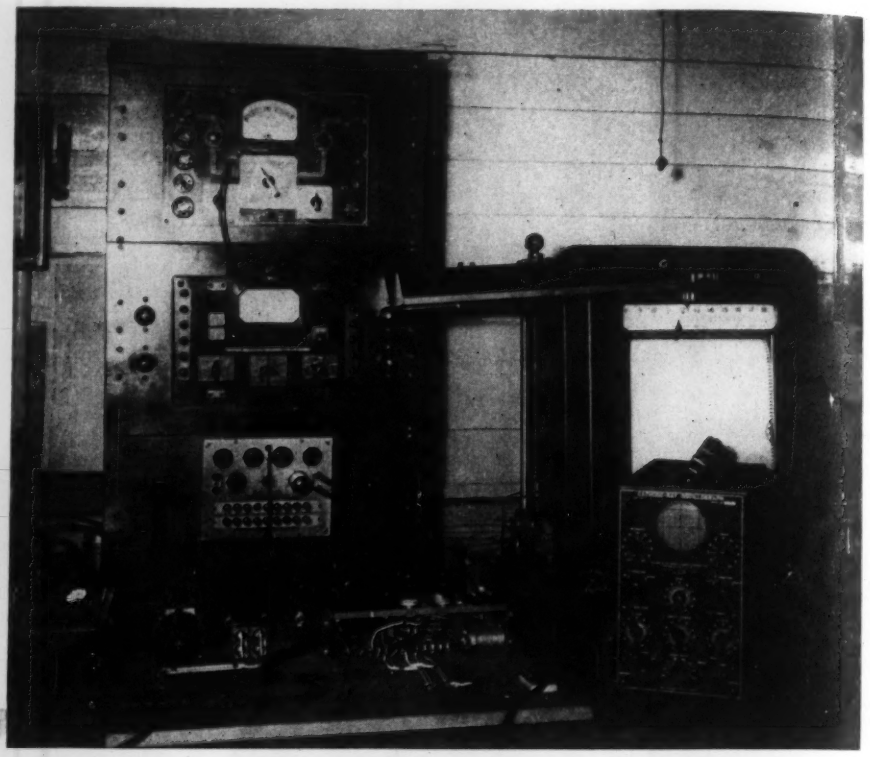


Fig. 6. Electrical Test Bench showing the Cathode-ray Oscillograph set up for checking converter in the foreground and in the background a test panel which contains (from top to bottom) a tube checker, emission type, a Volt-Ohm-Milliameter), a free point checker, and a row of switches to connect the jacks into appropriate circuits.

An automatic proportional sampler has been developed which automatically collects a small sample of a liquid flowing in a line at a rate proportional to the rate at which the line fluid is flowing. This is done, in brief, as follows: the output air from a remote flow transmitter, whose orifice is located in the process line being sampled, is fed to the diaphragm motor taken from a control valve. This diaphragm motor is connected to the adjustment rod of a Bosch pump and regulates the discharge of the pump in proportion to the flow. The pump removes a seal fluid from a sample bomb connected to the process line and the line fluid replaces the seal fluid in the bomb by its own flowing pressure. This gives a sample of about three gallons in forty-eight hours from a line carrying fluid at a rate of approximately 525 gph.

Conclusion

In conclusion it might be pointed out the principal, but not necessarily unique, features of Polymer Corporation's Instrument Division are its organization into comparatively small, compact, but highly flexible groups of instrument mechanics, the location of Instrument Division within the Production Control Department, the emphasis placed on knowledge of the process and complete coöperation with operating and technical personnel, the organization of "preventive" maintenance, and the continuous training program being conducted. These features have been incalculable in helping the group of comparatively green men service the (approximately) 2800 instruments, 1500 pressure gages and 600 thermocouples, with an installed value of some $1,200,000, which are entrusted to the division.

The author wishes to express his thanks and appreciation to the management of St. Clair Processing and Polymer Corporations who conceived and set up the present organization, and who have been themselves the finest example of the coöperation stressed above; to Mr. J. N. Franklin, first Instrument Engineer of St. Clair Processing Corporation; to the late Mr. J. C. Tighe for his invaluable work in conducting the original training program and assistance during the start-up period; to Mr. W. C. Ludi of the Standard Oil Development Company, who very materially helped during the difficult start-up; finally and especially to all the men of the Instrument Division without whose continued cheerful coöperation in the operation of the division all else would be as nought.

Design of Instrument Air Supply Systems for a Process Industry

By W. C. LUDI, Standard Oil Development Co., Elizabeth, N. J.

Introduction

In the design of any utility system for a process industry, certain fundamental principles are involved and carefully followed to provide an adequate and continuous supply of the utility, thereby assuring continuity of process operation and maintenance of product quality. Considerable study is therefore given in the process designs of a new operation to the utility requirements such as fuel, steam, power, cooling water and compressed air. Of equal importance to these utilities is the compressed air for the pneumatically-actuated process control instruments on whose successful performance depends the satisfactory operation of the process unit as a whole. This paper will deal with the design of the instrument air supply system and will attempt to outline the principal points to be considered in such a system to insure optimum efficiency of the control instruments.

Fundamental Requirements

For the successful operation of any pneumatic control system, compressed air having definite characteristics and qualities is required. The fundamental requirements are: reliability of supply, constant pressure, cleanliness and dryness. Most instrument air supply systems meet part of the requirements only.

Reliability of Air Supply and Constancy of Pressure.—The supply should be reliable, dependable and at a constant pressure for twenty-four hours a day, seven days a week. Otherwise many instrument failures will occur because of lack of actuating air. The actuating air supply may fail for only a very short time yet cause a process unit to be upset for a relatively long period. This usually has a serious effect on the products and frequently makes it necessary to reject the products during this period of upset. To have a source meet the requirement of reliability, it is desirable to have certain auxiliary equipment cut-in automatically when a condition of either partial or total failure of the normal supply occurs. Much consideration must be given to this point to assure that all possibilities of failure are engineered out of the system in the simplest and most positive manner.

In most large processing plants, the general yard air system appears at first glance to be a good source of supply. The air is usually available throughout the entire plant at reasonable pressures, at all hours, and might be assumed, therefore, that this air supply meets the requirements of reliability and constant pressure. However, this is not entirely true. The general yard air system being used for many purposes, such demands frequently result in reduced pressures at various points in the system. Examples are blowing out of lines, operation of all types of air tools, pressure testing of lines and vessels, and many other sundry uses. Assume that the air is being used to blow out a long line filled with caustic and that this operation might require thirty minutes. This is what can happen: The valve on the air line is opened into the caustic line and since some time is required, the operator will leave to perform some other functions. At the end of thirty minutes, the line will have been blown clear, and since no one is at hand to shut the valve, the air can blow free and to the full capacity of the line, causing a drop in pressure. Cases have been noted in such operations where the supply pressure has dropped to but a few pounds. Again, assume that air tools are being used and that pressure testing is also being carried out: these intermittent operations may cause severe pressure fluctuations that can drop the supply pressure to a point at which instruments will not operate satisfactorily. As a typical example where all three of the preceding operations were being carried out simultaneously, the supply pressure dropped from a normal 100 lbs./in.^{2} to 20 lbs./in.^{2} throughout the entire system. The demand on the system was such that the pressure was not restored to a satisfactory level for instrument operation (25-30 lbs.) for some time. As a result, instruments throughout the plant were controlling erratically and the operation was unsatisfactory.

Cleanliness.—In practice there are two types of contaminating materials which must be removed and kept out of the system to insure continuous trouble-free instrument operation, namely, oil and solid matter. The solid matter may be classified as dust, dirt and scale. These contaminants must be eliminated to assure delivery of clean air to the controller mechanism. As we all know, solid matter may completely plug nozzles, restrictions and pilot valves, resulting in complete controller failure. Oil can have as bad an effect as solid matter, as the oil often oxidizes and gums up the moving parts, resulting in erratic and unsatisfactory controller action.

A case comes to mind where a controller mechanism was dripping with oil which had been carried into it by the actuating medium. Investigation disclosed that an excessive amount of oil was being fed to the compressor to permit the oil to be carried into the air stream to assist in the lubrication of air tools. This excessive amount of oil caused a great deal of gum formation in the pilot valve and nozzles, requiring frequent cleaning of the controller mechanism.

Another instance was observed where the general yard air system was being used for the instrument air supply, and it was necessary to blow out a caustic line. Pressure in the caustic line was higher than in the air line, and when the air valve was opened, caustic backed into the air distribution system. Check valves had been provided, but they did not hold and caustic flowed into the air lines, thence into the instruments, severely corroding the controller mechanism and resulting in complete controller failure. Service interruptions and high maintenance costs were experienced until this caustic was completely eliminated from the air system.

Dryness.—Moisture is present in all compressed air and will be a constant source of trouble if not adequately removed. In some systems, aftercoolers are provided to remove some of the moisture, but in most cases they are inadequate.

Air at atmospheric conditions contains water vapor in varying quantities, the amount depending on specific atmospheric conditions. Air that is far from saturated under normal conditions, when compressed to a small volume and cooled to its original temperature, will precipitate moisture because the saturation point or dew point is raised by the reduction in total volume. During compression the temperature is raised and consequently the moisture may not condense out. As the air travels from the compressor to the point of use, it is cooled to the ambient temperature, thus reducing its moisture-carrying capacity and causing some of the water vapor to be condensed and to settle in the receiver, piping, tubing and instruments.

Moisture will have various ill effects, all of which will cause unreliable instrument performance and interruption of service. Some of the chief effects are as follows:

(a) Freezing of the water where low temperature is encountered, causing loss of air supply to a single control mechanism, a group of control mechanisms or an entire area.

(b) Corrosion of piping and connections, causing rust scale, dirt and dust.

Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept. 16-20, 1946.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

(c) Condensed water vapor and any entrained oil in the air can become emulsified, resulting in fouling of the control mechanism.

An example of what can happen to control systems when instrument air is improperly dried may be cited: A plant was visited where the control equipment had been giving poor results, mostly during the night and early morning. After considerable observation during these periods of upset, it was discovered that quantities of water caused by the low temperatures existing during these hours were getting into the control mechanism. In one particular instrument which was at the end of the air line, water was squirting from the pilot valve and nozzle at frequent intervals. Examination showed approximately two inches of water in the bottom of the instrument case.

When such conditions prevail, it is impossible to get the most out of control equipment and to have continued satisfactory operation. The effect on the operating personnel's morale is bad, and confidence in the control equipment is lost, with the result that for the slightest reason — whether the instruments are performing properly or not—hand control is quickly resorted to. When control equipment is put on hand control, frequently more operating personnel and instrument technicians are required, increasing operating cost unnecessarily. Many factors are involved when economically justifying an expenditure of money to properly condition the instrument air. To date, no comparative cost figures are available on instrument maintenance with an air system meeting the above requirements and one which does not. Also, no figures are available as to the portion of the costs due to product rejection and reduced plant capacity which might be chargeable to instrument failure. It is believed that if these figures were available, they would prove that the installation of a good instrument air supply system would pay a handsome return on the investment. This is emphasized by the fact that many oil refineries now have systems including all portions recommended and some refineries have such programs included in their future construction.

Types of Instrument Air Systems

The following are some of the types of air systems which may be used and will meet the principal requirements.

1. A central system entirely isolated for instrument actuation only. This system requires a compressor and necessary standby equipment, aftercooler, separator, air receiver, drying equipment and distribution system.

2. Using the general yard air compressors when they are reliable but giving instruments preference over all other users. Instrument air for this system is taken at the air receivers before it enters the general yard air distribution system. This requires control equipment at the receiver to insure that the instrument system has preference over all other users, an aftercooler if none is used between the compressors and air receiver, a separator, drying equipment and distribution system.

3. Using the general yard air compressors when they are reliable and the general yard air distribution system, but installing necessary auxiliary equipment within each process unit or area to assure a uniform pressure. This requires a small auxiliary air compressor at each process unit or area to cut in automatically when the yard pressure drops below safe operating pressure. Also required at each take-off from the yard system are an aftercooler, separator, receiver and drying equipment.

4. Individual air system at each process unit or area. This requires equipment essentially the same as that described under Paragraph 1, but on a much smaller scale. This system has the drawback that when small compressors and auxiliaries are used, it is difficult to obtain machines to give long life and minimum carry-over of oil.

Many other systems can be devised which will probably meet the principal requirements, but the four outlined cover the main variations. It is believed that the isolated system complete within itself as described in Paragraph 1 will insure the best compressed air for instrument actuation and allow control equipment to operate free of actuating medium problems.

Design of an Instrument Air Supply System

Assume that an instrument air supply system is required for a plant havtral system, isolated for instrument acing eight process areas and that a centuation only, will be used. Before such a system can be designed, the following information is required: (a) pressure desired at the process areas; (b) air requirements in standard cubic feet per minute; (c) maximum and minimum atmospheric and cooling-water temperatures.

Pressure Requirements. — Most instruments require an air supply at approximately 20 lbs./in.^{2}, with a few exceptions. With a reducing valve preceding the instrument, some pressure drop must be allowed for its operation, and most such reducing valves perform satisfactorily with a 5-lb. pressure drop. On this basis, pressure at the process area should be a minimum of 25 lbs./in.^{2}. Experience has indicated that leeway must be allowed in the systme for flexibility; hence a 35-lb. supply pressure at the process area appears to be satisfactory for most all conditions. Approximately 45 lbs. is required at the central station, which allows for a 10-lb. pressure drop through the drier and distribution system.

Instrument Air Consumption. — Air consumed by an instrument is a much-discussed point; and widely-varying figures are quoted. To clarify this point, Figs. 1, 2 and 3 are given, which show actual instrument air consumption records of process units. Fig. 1 was taken from a plant in which the majority of the instruments have the non-bleed pilots. It will be noted that the normal total flow on the chart is 3.4, and the maximum flow is 4.6, which occurred during a general plant upset. Ninety-one consuming mechanisms (pilots) were included in this plant, making the normal consumption 0.35 standard cubic

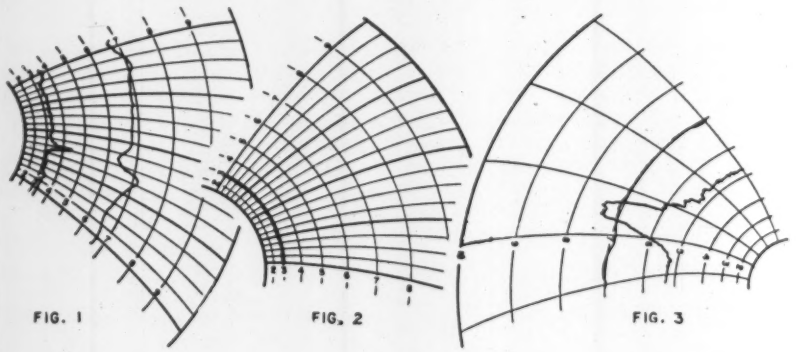


FIG. 1 FIG. 2 FIG. 3

feet per minute per pilot, and maximum consumption 0.44 scfm. per pilot. Fig. 2 was taken from a plant in which all the instruments have bleed type pilots. In this case, the air is consumed at a constant rate. The total number of consuming pilots in this plant is 90, and consumption per pilot is 0.46 scfm. Fig. 3 is similar to Fig. 1 in that the majority of instruments have non-bleed pilots, and here again the air consumption per pilot varies between 0.32 and 0.45 scfm. When non-bleed pilots are used, the air rate varies considerably, but to design an air system the maximum air requirement must be available during an upset condition, and therefore it is necessary to design for this condition. A review of these data indicates that 0.5 scfm. per pilot is a good figure to be used as the rate of consumption of each consumer regardless of pilot type.

A tabulation of typical consumers within a single process area is given in Table I. Each type of consumer is weighted in order to arrive at a common basis. The weighting factor is based on the type and number of pilots, since some types of pilots use more air than others.

Table II is a tabulation of the air requirements for a complete plant, showing a total air requirement of 267 standard cubic feet per minute. To this figure a factor of at least 15 to 20% must be added to take care of leaks, blow-down and future instrument additions. In deciding on the magnitude of this factor, consideration should be given to future expansion, stability of process relative to future redesign, etc. Based on this tabulation and allowing

for future instrument additions, the air supply system should be designed for 310 standard cubic feet per minute.

Temperatures Encountered—In order to avoid deposition of moisture in the air supply system, the air should be dried to a dew point of 5 to 10°F. below the ambient temperature before it enters the distribution system. For design purposes, in the example being considered, the maximum and minimum temperature encountered are 95 to 50°F. summer conditions, and 0°F. minimum in winter. Cooling water temperatures vary from 75 to 35°F.

TABLE I

Type of Instrument	Number	Weight factor	Equiv't users
Remote (air transmission type) recorders	14	1	14
Remote (air transmission type) controllers	17	2	34
Mechanical (local) controllers	9	1	9
Temperature controllers	5	1	5
Temperature controllers	1	2	2
Valve positioners	10	2	20
Pilot-operated regu'ators	2	1	2
Miscellaneous users	4	1	4
Total Users			90

Some temperature controllers have been given a factor of 2 because of the number of pilots in their control mechanism. Experience and tests have also indicated valve positioners to be large consumers, and the condition of the valve can also seriously affect the consumption rate. For these reasons, positioners also have been given a factor of 2.

TABLE II

Process area	No. control instruments	No. Pilots or users	Air req'd per unit std cfm.
A	52	70	35
B	58	90	45
C	48	78	39
D	76	112	56
E	22	32	16
F	12	16	8
G	96	136	68
Total air required			267
Add 15% for leaks and future instruments			40
			307

Design the system for 310 scfm.

Equipment Required

Fig. 4 is a line diagram for an isolated instrument air actuation system, showing all the pertinent equipment required such as compressors, aftercooler, separator, receiver and drier. For the design conditions of the case under discussion, the following specific comments on equipment choice are given.

Compressors.—Two air compressors should be provided, each having a minimum actual free air capacity of 310 cfm. at 45-55 lbs./in.^{2} discharge pressure. If steam and power balance permits, one compressor should be motor-driven for normal operation, and one should be steam-turbine-driven for stand-by service. These machines should be of the heavy-duty continuous-service slow-speed type, shown to give minimum maintenance and maximum trouble-free service. Cylinders should have force-feed lubrication with means of adjusting the lubricating oil feed rate. Splash lubrication of the cylinders should be avoided in order to minimize oil entrainment. The suction side of the compressors should be provided with a dry type filter for removing atmospheric dust and dirt. A pressure unloading system should be provided to maintain the output pressure between 45 and 55 lbs./in.^{2}.

The stand-by compressor should be arranged to start automatically whenever the discharge pressure drops below 40 lbs./in.^{2}, or in the event of failure of the motor-driven unit. Obviously, if there were no steam-turbine-driven stand-by, power failure would leave the plant without any air supply. The turbine governor of the steam driver should be suitable to control the speed of the turbine under all normal operating conditions in order to eliminate any possibility of having the emergency overspeed trip shut down the turbine when the compressor unloads.

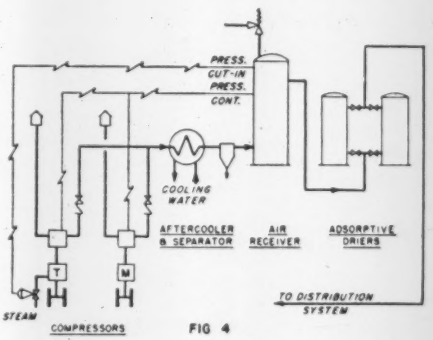


FIG 4

The compressor suction should be located at a point outside the building, so that atmospheric contamination due to local conditions will be kept at a minimum.

Aftercooler, Separator and Receiver.—To cool the air and remove as much moisture and oil as possible by simple means, an aftercooler (with integral separator) and a receiver should be provided at the discharge of the compressors, arranged so that it will serve either compressor. An automatic condensate trap should be supplied to eliminate separated moisture and oil from the aftercooler and receiver. The aftercoolers are normally sized to cool the air within 15°F. of the inlet water temperature. The air receiver is normally sized to have a capacity equal to the compressor output for at least one to one and one-half minutes operation. As an example, for 310 scfm. output and a discharge pressure of 45-55 lbs./in.^{2}, the receiver should have a volume of 67 to 100 cubic feet.

Driers.—Two principal methods of moisture removal from compressed air may be used, namely, (1) cooling, and (2) absorptive drying.

The cooling method alone can be used in locations where it is possible to cool the air 10°F. or more below ambient without having the cooling medium below 35°F. When cooling is the only means of drying, such cooling should be done before the receiver. It should be noted that even when absorptive drying is used, the aftercooler itself, is, in effect, a partial drier and serves to reduce the load on any subsequent drying apparatus.

For the typical case under discussion (310 scfm.), the ambient temperatures are such that the cooling method cannot be used alone; therefore, the absorptive drier must be added. An absorptive type drier should be provided through which the air shall pass before entering the distribution system. This unit shall be designed for the capacity of one compressor with air entering at 55 lbs./in.^{2} saturated with water vapor at 90°F. for the summer condition and 50°F. for the winter condition, and shall be capable of maintaining a dew point of 40°F. for summer conditions and —10°F. for winter conditions at the outlet. The drying unit should be of the dual tower type for eighft-hour drying cycle design for semi-automatic operation. The dryer should be water-cooled and designed for either steam or electric reactivation.

It is interesting to note that these driers, when designed for summer conditions, will be amply large for the winter conditions. The duty requirements are not as severe at low temperatures as at elevated temperatures. Driers for such a system may be purchased complete with all reactivating equipment.

To summarize, operating experience has indicated the desirability of providing separate air facilities for the actuation of pneumatically-operated control equipment. Such a system, when properly designed, provides air at a constant pressure in adequate amounts to insure continuous and uninterrupted operation of all process equipment. It provides properly-cleaned and moisture-free air so that instrument difficulties are minimized.

It is firmly believed that where such a reasonable expenditure assures trouble-free operation of air-actuated instruments, the tangible return in reduced off-quality product will justify the necessary investment. Aside from this return is the intangible factor of faith of the operating personnel in the ability of control instruments to perform their functions within the process unit. When this faith is lost the investment represented by the idle instruments (which in some cases may be substantial) is also lost. The general all-around importance of instruments is slowly being realized, and for them to maintain their position in importance it is essential that all care be taken to allow them to operate with the best possible efficiency.

Many oil refineries have installed trial installations including all portions of the system recommended. These refineries, having satisfied themselves as to the economics from the results of these trial installations, have included such systems in their recent construction programs and some companies are committed to it for all future work.

On the Relation of Instrumentation to Quality Control

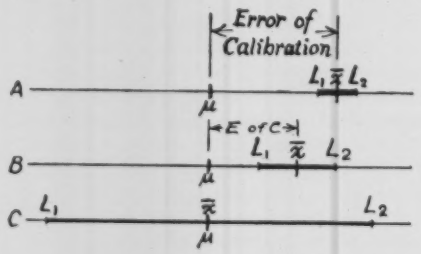
By COLONEL LESLIE E. SIMON, Ord. Dept., U.S.A. Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

IMPORTANCE of Measurements. In scientific work it is often with measurements that our knowledge of new things begins; in business and manufacture almost all of our relations depend upon measurements. Yet many persons never pause to consider that all measurements are approximate only. The degree of approximation can be made as small as one chooses, if one is willing to pay the price. Hence, precision of measurement is an economic matter.

Kinds of Errors. There are three primary sources of error or variations in measurement: (a) errors of the operator, (b) errors of the instrument, and (c) variation in the product which is being measured. Thus it is obvious that no intelligent consideration of precision of measurement or of cost of measurement is possible without a consideration of the precision of the instrument. Furthermore, in considering the variations which arise from each of the three sources one must make a distinction between two kinds of errors: accidental or random errors, and systematic or constant errors.

Precision refers to the deviation of a measurement from similar measurements and is associated with mere reproducibility; *i.e.*, the measurement is precise if upon repetition the individual measurements taken on a single characteristic cluster closely together. If the variability is small then the measurement is *precise* but not necessarily *accurate*. Accuracy refers to the deviation of the measurement from the true value. Accuracy requires both correctness of calibration and precision.

In the following sketches, let μ be the true value, $\bar{x}$ the level of the measuring instrument, and let L_1-L_2 represent the interval of dispersion in measurements for the instruments A, B, and C. It is assumed that the interval L_1-L_2 for each instrument is based on a very large number of measurements.



For a single measurement, instrument A is more *precise* than instrument B but is a priori less *accurate* because of its error in calibration. On the other hand, instrument C is calibrated correctly but is neither as accurate nor as precise as instruments A and B since the range in measurements of C more than covers the corresponding ranges of A or B. However, the average of a large number of measurements from instrument C will be more accurate than a similar average from either A or B.

An Example Illustrating the Components of the Three Sources of Error. The three sources of errors are each associated with accidental and systematic errors. At the risk of being trite I should like to illustrate these six kinds of variations by a homely example, the use of a yardstick by a clerk in a store selling yard goods.

A first consideration is errors of the operator. The clerk undoubtedly makes random errors, dependent upon how he pinches the cloth, how much he is distracted by a pretty face, or perhaps on the proximity of lunch time. The proprietor and the public hope that these errors will be compensating. Also the clerk may make systematic errors (bias of the operator) especially if he is motivated by the same influence which causes the butcher to repeatedly weigh his thumb while the unwary customer watches the dial of the instrument instead of the operator. Purchasers generally accept these hazards as an inevitable consequence of the venality of mankind.

Second, there are errors of the instrument. A cheap yardstick is almost certain to possess a systematic error of several hundredths of an inch, even when new; but what is this error compared to the stretch of the cloth? Certainly we are not going to specify that the cloth shall be measured while suspended horizontally under a tension of x pounds, at an ambient temperature of y degrees and a relative humidity of z percent. In like manner, the stretch varies randomly as a function of the temperature, humidity and other parameters.

Third, there is variability in the product. The cloth varies systematically with changes in the manufacturing process, kind of cloth, and age; and varies randomly with short-term variations in the weaving and with the weather.

It is evident that the customer gets only approximately the length of the cloth for which he asks. However, it would not be economical to go to considerable expense to insure greater accuracy or precision; and it appears that the yardstick is not an uneconomical instrument for small vendors, although many large stores have apparently considered it economical to change over to cloth-measuring machines.

Action to Reduce Errors. Several types of action may be taken to reduce errors of variability and certain laws can lead us to swift and intelligent corrective action. (1) Errors of the operator are generally reduced by careful selection of operators, by repetition of measurement and taking the average, or by instrument design, *e.g.* making the least count of the instrument sufficiently small while at the same time requiring a reading scale which is not easily mistaken. (2) Systematic errors of the instrument are reduced by calibration. In this connection, it is desired to point out clearly that systematic errors of measurement may vary from day to day, and from experiment to experiment, and thus fall naturally into the realm of statistical methods of quality control. Hence, calibration is generally a statistical problem and should be treated accordingly. Accidental errors of the instrument are reduced by good instrument design, fine workmanship, and proper operation. (3) Variation in the product requires no action, unless the measurement is being made in connection with control of quality of the product in the process of production: we merely observe the variation and take appropriate action such as rejection of the product or appropriate grading of the product.

Accumulation of Errors. The total systematic error of a system is the algebraic sum of the systematic errors. The total accidental error or random error of a system is the square root of the sum of the squares of the random errors. Accidental error or variation is generally expressed as the standard deviation, *i.e.* the root-mean-square-deviation. The practical importance of these considerations can be best seen from a few illustrations.

An Unusual Calibration for Systematic Error. One of the principal products of Aberdeen Proving Ground is measurements. If measurements are poor, a good product may be rejected because of error in measurement rather than variability in the product. In like manner a poor product may be accepted because the measurement is poor. Moreover, measurements should not be too costly. Consequently, a great deal of attention must be paid not only to precision and accuracy of measurement but also to *economy* of measurement. The selection of proper instrumentation and careful calibration are of paramount importance.

One of the more common measurements made in the acceptance testing of complete rounds of ammunition is the measurement of the velocity of the projectile when it is fired from a standard gun. The velocity of a projectile is measured by finding the time required for the round of ammunition to

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NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

traverse a fixed distance between two "screens" placed at appropriate distances in front of the gun muzzle. Although the distance between screens is measured accurately and we have timing standards with a fundamental frequency of 100,000 cycles per second, we find that in firing samples from a single homogeneous lot of ammunition we are not always able to reproduce within chance limits the same level of velocity on different days. That is, on one day we obtain an average velocity of 1020 fps., whereas using the same measuring set-up on another day we may obtain an average velocity of 1028 fps. and the difference of 8 fps. cannot be reconciled. This variation in level of the measuring set-up from day to day is due to many different factors and generally speaking it would be very time-consuming and uneconomical to attempt to eliminate such differences from our instrumentation. At any rate, the variation in muzzle velocity from a prescribed level on a particular day is referred to as "the error of the day" which is none other than a systematic error due to the measuring set-up. We handle the problem by estimating accurately and taking cognizance of the "error of the day" in a particular problem. The method of effecting such an instrumental calibration is an interesting statistical problem that has been discussed elsewhere.*

Product Variations. Random and systematic variations in the product or item we are measuring are of a similar nature to those in instrumentation. For example, consider piece parts being turned out by an automatic screw machine for a given fixed setting of the machine. I believe we all realize that the parts produced during a given period of time would vary in some particular dimension owing to non-homogeneity of raw materials, cutting-tool wear, temperature, and inherent variations in the moving parts of the automatic screw machine itself. The amount of variability among the individual piece parts for some particular dimension when expressed as a measure of dispersion (such as the standard deviation) gives the random variation in the product. On the other hand, the automatic screw machine may not have been set accurately to begin with; hence, the average dimension of the parts being turned out by the machine may differ systematically from the prescribed dimension. The deviation of the average dimension from the desired value is an example of systematic error in the product which can be easily identified and measured by the Shewhart control chart.**

Importance of Instrument Calibration. Recapitulating somewhat, we say that random variations of the measuring instrument may be determined by carrying out repeated measurements on the same dimension and that the systematic error of a measuring instrument is actually the deviation from the absolute or true value of the dimension. It is to be noted here that actually the deviation from an absolute value is in practice a relative thing and is taken as the comparative difference between the level of the measuring instrument and some standard *agreed to by all parties concerned.*† Systematic error of the measuring instrument may be determined, of course, by statistical calibration with an accepted standard. Random variation in the product is a measure of the variability among the individual items produced and systematic error is the deviation in the true average of the product from a desired value. In this connection, systematic error of the product can be measured only when the systematic error of the measuring instrument is known and the systematic error of the instrument is known only when a standard is agreed upon. Thus, we see the importance of proper calibration of measuring instruments against an accepted standard, including estimates of both the random and systematic errors of instruments.

Owing to inherent changes in measuring instruments from time to time, calibrations must be of a continuous character. In manufacturing plants where a large number of measuring instruments are required and where high precision is needed, a procedure should be established whereby instruments are calibrated and the random and systematic errors are indicated on the instrument. A calibration system gives the manufacturer important and valuable information. A knowledge of precision and accuracy of instruments is just as important as a knowledge of precision and accuracy of machines in determining whether or not a given product can be made properly and economically.

Relation of Instrumental Variation to Product Variation. An important point in the selection of instruments and in the design of a system of instrumentation is the relation between the random error of the measuring instrument and the random fluctuations in the product under measurement. In this connection, one would not like to attempt to measure variations in a product whose standard deviation is, say, 0.001" with an instrument which possesses a random error equal to 0.01". Moreover, as far as economical manufacture of a measuring instrument is concerned, it would not be advisable to design an instrument (for the above example) which would have a random error of measurement equal to say 0.00001" as the cost of the instrument would probably be prohibitive and such precision is not warranted.

At the Ballistic Research Laboratory, a great deal has been done to determine separately the random variations in the measured product and random variations in the measuring instrument itself. The separation is necessary in judging the reliability of instruments and in acquiring appropriate design data for products. The analytical process of separating sources of variation is not entirely simple, but the procedure can be shown easily by an example.

Analytical Separation of Sources of Variation. In Table I there are listed the individual fuze burning times as measured by each of three observers on 30 rounds of ammunition which were fired from a gun. The powder train fuzes were all set for a burning time of 10 seconds.

TABLE I

Fuze Burning Times (seconds)			Mean Times (seconds)
Observers			
A	B	C	
10.10	10.07	10.07	10.080
9.98	9.90	9.90	9.927
9.89	9.85	9.86	9.867
9.79	9.71	9.70	9.733
9.67	9.65	9.65	9.657
9.89	9.83	9.83	9.850
9.82	9.75	9.79	9.787
9.59	9.56	9.59	9.580
9.76	9.68	9.72	9.720
9.93	9.89	9.92	9.913
9.62	9.61	9.64	9.623
10.24	10.23	10.24	10.237
9.84	9.83	9.86	9.843
9.62	9.58	9.63	9.610
9.60	9.60	9.65	9.617
9.74	9.73	9.74	9.737
10.32	10.32	10.34	10.327
9.86	9.86	9.86	9.860
10.01	lost	10.03	10.020
9.65	9.64	9.65	9.647
9.50	9.49	9.50	9.497
9.56	9.56	9.55	9.557
9.54	9.53	9.54	9.537
9.89	9.89	9.88	9.887
9.53	9.52	9.51	9.520
9.52	9.52	9.53	9.523
9.44	9.43	9.45	9.440
9.67	9.67	9.67	9.670
9.77	9.76	9.78	9.770
9.86	9.84	9.86	9.853

The burning time of a fuze is defined as the interval of time which elapses from the instant the projectile leaves the gun muzzle until the fuze functions the projectile in air. The times referred to in Table I are measured by means of electric clocks. A switch on the gun muzzle starts three different electric clocks as the gun is fired and each observer stops his clock the instant he sees the flash or burst of an individual round. Each timer, of course, stops his clock independently of the other two timers. In Table I is given also the mean time of the three observers on individual rounds. The average time-to-burst of the 30 fuzes is taken as the average of the 30 mean times with the effect of reaction time (which is known accurately) subtracted therefrom. Our problem is to determine whether the electric clock is a satisfactory instrument for this purpose, provided the electric clocks are properly calibrated with regard to average time so that the systematic error of measurement may

*L. E. Simon, Application of Statistical Methods to Ordnance Engineering, *Journal of the American Statistical Association*, Sept. 1942.

**American War Standards, Control Chart Method of Controlling Quality During Production, Z1.3, 1942, Amer. Standards Assn., New York, N. Y.

†In the interests of brevity and simplicity the concepts of accuracy and precision are treated in an approximate and elementary way. For a scientific discussion the reader is referred to Chapter IV, *Statistical Method from the Viewpoint of Quality Control*, Shewhart, the Grad. Sch., D.A., Wash., D. C., 1939.

be reconciled. We answer this question by comparing the random error of measurement with the random error of burning times of the fuzes.

In Table II there are given the algebraic differences between times of the three observers A, B, and C on each round.

TABLE II
Difference Between Observers' Times (seconds)

A-B	B-C	A-C
+0.03	0	+0.03
+0.08	0	+0.08
+0.04	−0.01	+0.03
+0.08	+0.01	+0.09
+0.02	0	+0.02
+0.06	0	+0.06
+0.07	−0.04	+0.03
+0.03	−0.03	0
+0.08	−0.04	+0 04
+0.04	−0.03	+0.01
+0.01	−0.03	−0.02
+0.01	−0.01	0
+0.01	−0.03	−0 02
+0.04	−0.05	−0.01
0	−0.05	−0.05
+0.01	−0.01	0
0	−0.02	−0.02
0	0	0
...	...	−0.02
+0 01	−0.01	0
+0.01	−0.01	0
0	+0.01	+0.01
+0.01	−0.01	0
0	+0.01	+0.01
+0.01	+0.01	+0.02
0	−0.01	−0 01
+0.01	−0.02	+0.01
0	0	0
+0.01	−0.02	−0.01
+0.02	−0.02	0

It is to be noted that any one of the differences listed is not influenced by the level of burning time of an individual fuze and represents the actual difference in measured times between the two observers involved. Thus, some estimate of dispersion such as the variance (i.e. standard deviation squared) of each of the columns headed A-B, B-C, and A-C, gives us the variability of the difference between the two observers compared. It is a fundamental law in mathematical statistics that the variance of the difference of two variables is the sum of their variances, provided that the two variables are not correlated. Therefore, taking the variance of a three columns in Table II, we arrive at the following three equations:

$$\sigma_A^2 + \sigma_B^2 = 0.0007030 \text{ sec.}^2$$

$$\sigma_B^2 + \sigma_C^2 = 0.0003108 \text{ sec.}^2$$

$$\sigma_A^2 + \sigma_C^2 = 0.0008878 \text{ sec.}^2$$

Using these equations, we can solve for the standard deviations in measurement of each observer, that is, for σ_A, σ_B, and σ_C. These are found to be:

$$\sigma_A = 0.0253 \text{ sec.}$$

$$\sigma_B = 0.0079 \text{ sec.}$$

$$\sigma_C = 0.0157 \text{ sec.}$$

The above figures give a direct comparison of the ability or precision of each of the observers. It is seen that observer B is the best of the three since he has a precision or standard deviation of only 0.0079 second, whereas observer A is the poorest timer of the three. As a matter of fact, one can look at the columns in Table II headed A-B and A-C and note that for the first ten rounds or so observer A had a definite lag in stopping his clock as compared to the other two observers.

Returning now to Table I, we will examine the random error in burning times of the fuzes. This is determined by computing the standard deviation of the mean times given in the fourth column of this table. This measure of dispersion is found to be 0.2147 second. It is noted that the random variation in the product is about nine times the standard deviation in measurement of the poorest timer, whereas it is about 27 times that of the best timer. This is an example where the measuring instrument is quite adequate for the purpose at hand and it might be said that the errors of measurement of the combination including electric clocks and observers are small enough to preclude rejection of a good lot of fuzes or acceptance of a poor lot of fuzes due to random errors of measurement. Since actually the average time of three observers is used in estimating the burning time of a fuze, we should properly compare the resulting random error with that of the product. The random error of measurement for an average of the three observers turns out to be approximately 0.0178 second. Thus, it is seen that the burning times as recorded, using averages of three observers, has a random error of about one-twelfth the variability of an individual fuze burning time. As a final point concerning this example, I mention that the standard deviation of fuze burning times, *i.e.* 0.2147 second, actually includes the random error of measurement. Upon adjusting the figure of 0.2147 for the random error of the instrument, the estimate of standard deviation of only fuze times turns out to be 0.2140 second, thus indicating the negligible effect of the measuring technique.

A rigorous general statement concerning the relation between random error of instrument and random variability of product cannot be made as this properly depends on the particular practical circumstance. In some cases, it will be satisfactory and economical for the random error of the instrument to be one-half that of the variability in the product measured. In other situations, we may desire more precision in our instrumentation.

Summary. In conclusion, I should like to say that these concepts of sources of error and kinds of variation contribute much towards a rational basis for design, procurement, and operation of instruments. Moreover, instrumental errors and product variability go hand in hand and a complete analysis of the factors involved is a job for the engineering statistician or quality control engineer. Much is to be gained from economic and quality standpoints in knowing the (1) random error of the instrument and (2) systematic error of the instrument. Ideally the instrument laboratory of every establishment would have every instrument marked with two numbers. One number would be the systematic error of the instrument and the other would be the standard deviation of measurement of the instrument. If the systematic error varies throughout the range of the instrument, then a series of numbers should appear under the systematic error and these would constitute the calibration of the instrument. In like manner, if the magnitude of the standard deviation varies throughout the range of the instrument the random error would also be a column of figures which would show the standard deviations encountered throughout the range of the instrument. With these items of information an intelligent choice of instrument could be made for each kind of measurement. The selection of two precise an instrument results in wasted usage. The selection of an instrument that is too imprecise results in uneconomic action. A general rule which, of course, is not universally applicable is that the *standard deviation* of measurement of the instrument should not exceed one-half the standard deviation permissible in the over-all measurement of the product. Thus, if we neglect the error of the operator and consider only the variation of the instrument and the variation of the product, the standard deviation of the instrument should be only about one-half of the standard deviation of the product. The soundness of this rule is easily seen if we consider a 30°-60° right triangle in which the shorter leg is proportional to the standard deviation of the instrument; the longer leg proportional to the standard deviation or variability in the product; and the hypotenuse proportional to the standard deviation of the measurements of the product. Thus, the lengths of the three sides are proportional to one, the square root of three, and two, It is easily seen that further shortening of the short leg of the triangle (reduction of instrumental error) will have little effect upon the length of the hypotenuse and that efforts to reduce this sort of variation will not be remunerative unless the efforts cost relatively little.

Finally, it is obvious that much is to be gained both from the economic and quality control standpoints by knowing (1) the random variation in the product and (2) the systematic deviation of the product. It is believed that these points require little comment because these are the end points of almost all measurements and of almost all instrumentation. It is obvious that a knowledge of these two things depends entirely upon good instrumentation and quality control analyses from the statistical viewpoint.

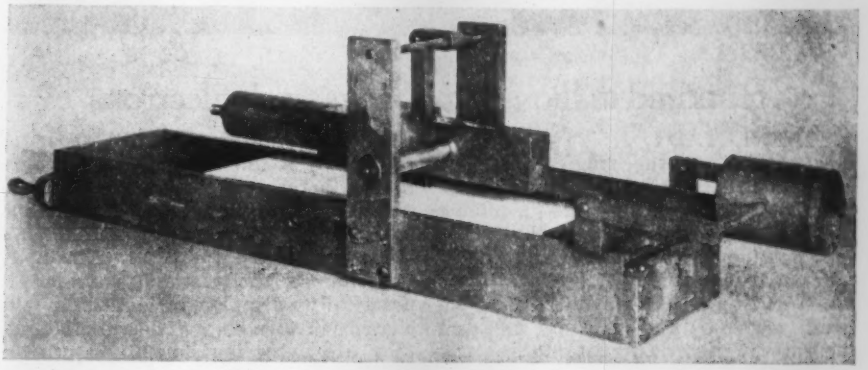
I wish to acknowledge my indebtedness to Major Frank E. Grubbs for general assistance, criticism, and the data connected with Table I.

Fourteen Years of Surface Wearability Testing With One Simple Instrument

By P. W. PROUTY, Electrical Appliance Engineer, Westinghouse Electric Corp., Springfield, Mass.

REPRODUCIBLE tests to determine the mar resistance, hardness and adhesion of organic protective coatings have been obtained over a period of fourteen years at the Springfield Works of Westinghouse Electric Corporation by means of a special testing instrument utilizing a simple Carboloy cemented carbide tipped cutter.

In testing organic finishes such as paints and varnishes, small steel panels are painted with the material, cured; and aged before the test is run. To determine the degree of mar resistance, hardness, and adhesion of the paint or varnish, a test was originated at the Springfield Works wherein a sharp metal blade under uniformly varying weight cuts through and eventually removes the organic finish under examination. This test is performed on the instrument shown in the accompanying photograph. As in all physical testing, it is imperative that the device used be capable of giving reproducible results over a long period of time so that the test results can be duplicated.



Mar resistance, hardness, and adhesion of paints and varnishes are determined at Westinghouse on this tester which utilizes a uniformly varying weight and a Carboloy-tipped cutting tool.

Inasmuch as some of the organic finishes tested are quite hard, and some of the priming and filling coats contain gritty material, it was desirable, in order to obtain consistent results, to use a cutting tool which would not wear rapidly. Carboloy cemented carbide—a product of powder metallurgy and a metal whose hardness approaches that of the diamond — was selected since it possesses probably the greatest resistance to wear of any metal. A tip of the hard carbide metal, ground and lapped to a keen edge, was placed on the cutting edge of the tool in the testing device.

When a sample of organic finish is being tested for mar resistance, hardness, and adhesion, the soft steel panel covered with the material is placed on the plane table of the tester, which moves back and forth. Over the test panel is a tool post with the Carboloy tipped cutting tool in it. This tool can be moved and pressed down so as to cut the painted surface. As the panel table moves, it shifts the counterbalance weight back and forth on the lever, which results in a uniformly varying weight on the cutting tool. At the start of the test, 500 grams weight is applied to the cutter; as the cutter moves, the weight increases until it reaches 5000 grams at the end of the stroke. The simple geometry of the linkages assures uniformity of the pressure-distance curve in all tests—those made fourteen years ago and those made today.

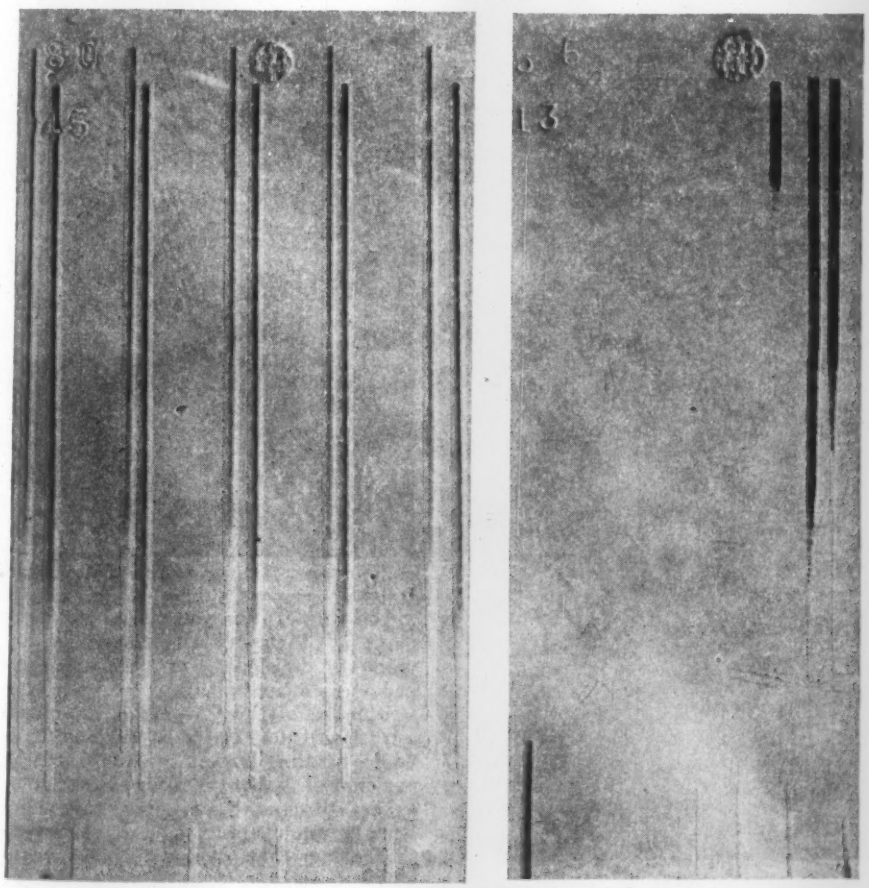
The point at which the cutting tool starts to scratch the surface of the organic finish is taken as the measure of the material's *mar resistance ability.*

The point at which the Carboloy tip cuts in and starts to remove the top coat of paint is considered to be an indication of the *hardness of the film.*

The point at which the carbide tool cuts through to the metal of the panel is designated as the *adhesion figure.*

After this point—and to the end of the stroke—the tool removes the steel of the test panel in a manner similar to the way in which a planer tool removes metal from a workpiece.

During the fourteen years that the Carboloy cutting tip has been in constant service, it has had to be re-dressed but once: because of abuse, not because it would have required sharpening at that time under normal conditions of use.



Typical specimens after undergoing tests.

INSTRUMENTS ON THE MARCH

Hundred-million-volt X-rays and Electrons

SCHENECTADY, N. Y.—"We have now arrived at the stage where we can generate in the laboratory radiations which formerly were available only in the cosmic rays, and we are just passing the borders of an entirely new field of atomic research." This statement by Dr. C. G. Suits, G-E vice president and director of its research laboratory, referred not to atomic bombs but to the laboratory's 100,000-000-volt induction electron accelerator, or betatron.

It was four years ago that the announcement was made that such an instrument was to be constructed.* In the summer of 1943 the betatron went into operation, but secrecy prevailed on all work related in any way to the field of nuclear physics so, even though not a part of the atomic bomb project, its completion went unannounced.

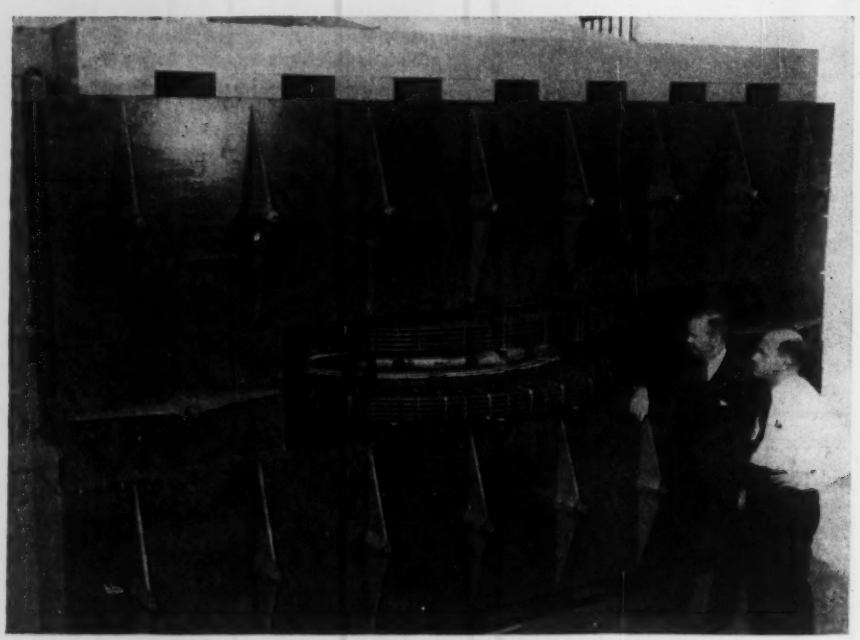
The new betatron produces x-rays far more powerful than any previously attained, as well as other interesting forms of radiation. It also gives greater depth doses of x-ray ionization in body tissue. Creation of matter from energy —reverse of the process in the atomic bomb—can be accomplished by its radiation. An ordinary half dollar can be made to give off rays like those of radium by a few minutes of exposure to the betatron's x-ray stream, with the silver transmuted to cadmium and palladium, and the copper of the coin's alloy transmuted to nickel. Within an hour or so the electron emission is practically completed. Although the changes involve huge numbers of atoms, they are exceedingly small in proportion to all the atoms in the coin, and no chemical test could detect the cadmium, palladium, or nickel so produced. The composition of the coin is not perceptibly altered.

The principal part of the betatron is a huge electromagnet, made of 130 tons of laminated silicon steel. It is 9′ high, 6′ wide, and 15′ long. In a rectangular opening (see photograph) are the pole faces, 75″ in diameter, surrounded by coils of insulated 1″ copper conductor. The magnet is energized by 24,000-volt 60-cycle current from a bank of capacitors, the intense magnetic field being concentrated in the horizontal space between the pole faces.

In this space between the pole faces is the heart of the instrument, a ring-shaped glass vacuum tube with an overall diameter of 74″ and an elliptical cross section 8″ across and 5″ deep. Electrons from an electron gun projecting into one of the 16 sectors of the tube are whirled in a fixed circular orbit for 1/240 of a second—whirled for 250,000 revolutions, and gaining about 400 electron volts with each trip. Just at the end of the quarter-cycle of 60-cycle current, a pulse of current passes through two small auxiliary coils on the pole faces, causing the electrons to spiral away from their orbit and strike a tungsten target, thereby producing the desired x-rays, which emerge from the tube in a narrow beam. By applying the trigger pulse sooner than the quarter cycle, x-rays of lower voltage are obtained —the betatron can produce x-rays from 2,000,000 to 100,000,000 volts.

The betatron is housed in a special building, with three-foot concrete walls. Control is necessarily remote, and comes from a neighboring room.

*See the description (longer than this one) in *Instruments*, Dec. 1942, pages 538-539.—EDITOR.



Dr. E. E. Charlton (left) and Dr. W. F. Westendorp, looking hardly older than in the photo in our Dec. 1942 issue which showed them in front of the then-unfinished betatron.

New Laboratory Devoted to Domestic Oil Heating

[SEE COVER PHOTO]

PITTSBURGH, Penna.—The placing in operation of one of the nation's largest and most modern fuel oil laboratories has been announced by Gulf Oil Corp. The laboratory, an addition to the Corporation's extensive research plant at Harmarville, Pa., will be devoted to developing greater efficiency in home oil heating.

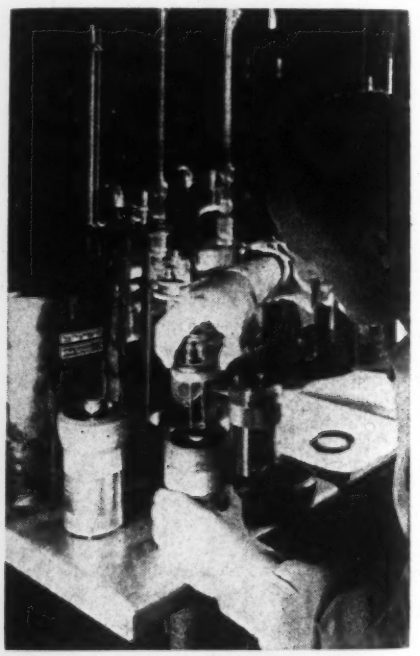


Fig. 2

Officials of the Corporation forecast a national increase of at least 50% in home heating by oil by 1950. Thirty per cent of persons planning new homes expect to heat by oil, they estimate. Burner manufacturers are said to be estimating that demand for burners will run as high as 500,000 yearly for the next five years.

The average burner today, providing clean, automatic heat, is 72-75% efficient—a high rating compared with solid fuels. The new laboratory will deal with problems of increasing efficiency, adapting fuels of new cracking processes to burner operation, overcoming problems of corrosion, improving atomization, and assisting in development of better fuels.

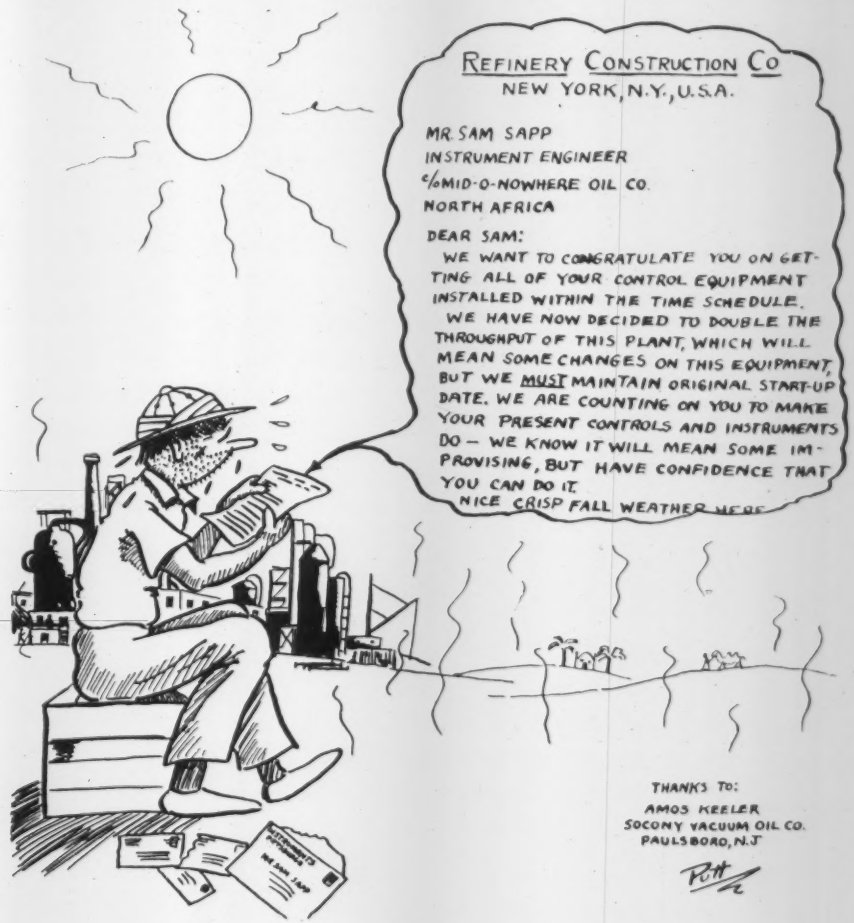
Fig. 1 [cover photo] is a view in the new fuel oil laboratory, showing some of the furnaces and equipment used in studying domestic heating with various types of burners and under all conditions of temperature and humidity. Tests are run for 70 hours with the burners set to run for 20 minutes and shut off for 10 minutes. During each run the operators take a number of measurements to determine the efficiency of the fuel oil. On each 20-minute operating cycle the oil consumption is measured; outside, room, fuel, and stack temperatures are recorded, along with barometric pressure and relative humidity. Stack and burner drafts, and analyses of the stack gases and smoke are also recorded.

Fig. 3

Shown in Fig. 2 is a bomb calorimeter used to measure the heat value of fuel oil. A gram of fuel is sealed in the bomb along with a charge of oxygen under pressure and immersed in a measured amount of water. The oil is ignited electrically and the resulting rise in temperature of the water indicates the heat generated.

Fig. 3 shows a technician using an electrical pyrometer for certain phases of combustion studies. The device enables examination of sections of the flame within the furnace and the determination of flame characteristics of various types of fuel oils and different kinds of burners.

WHEN A FELLER NEEDS CONTROL BY Putt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ALL ideas for these cartoons are sent in by readers, so send YOUR ideas to *Instruments*. (You have had experiences which were aggravating at the time but good for a laugh later.) Ideas should be presented in words and should not mention any specific manufacturer's equipment or trade name. *Instruments* will pay $5.00 for each idea used. Sender's name and company affiliation will be acknowledged in the cartoon unless we are specifically requested not to do so. Address Cartoon Dep't, *Instruments*, 1125 Wolfendale St., Pittsburgh 12, Penna.

Merchant-vessel Captain Reports Successful Use of Radar

SCHENECTADY, N. Y.—Initial reports on the first commercial radar installed on an American-owned and operated merchant vessel have revealed that after five months operation it has materially helped in maintaining sailing schedules with resultant savings in time and expense, according to officials of the American South African Line.

The General Electric electronic navigator aboard the line's flagship, the SS *African Star*, was installed and placed in operation on the ship's maiden voyage. Encountering fog and storms on runs between the United States and South Africa, the navigator helped materially to maintain the ship's sailing schedules, according to Captain C. W. Schmidt, master of the *African Star*.

Captain Schmidt cited a typical case in which the electronic navigator proved its effectiveness. "On a voyage from Port Elizabeth to Capetown, South Africa, heavy fog was encountered before rounding the Cape of Good Hope. In spite of this, with the radar operating, a speed of about 17.5 knots was maintained, and we arrived off Capetown breakwater at 4:00 p. m., the time previously radioed to our agents. Consequently, all arrangements made as to gangs, Immigration, and port authorities were not upset by a late arrival, and stevedores did not have to be paid for time awaiting ship's arrival."

The electronic navigator on the *African Star* is a "Model MN-1A" 10-cm. surface search radar specifically designed for use on merchant ships as a surface obstacle detector and navigational aid. Range selection of 2, 6,

or 30 miles radius is provided so that surroundings may be viewed on an extended or small-scale basis, depending upon the waters being navigated.

Powerful Electromagnet Aids Production and Research

PITTSBURGH, Penna.—An electromagnet so powerful that the operator must stay at the controls four yards away when it is at peak operation in order to avoid having his pockets picked has been developed by Dr. J. E. Goldman of the Westinghouse Research Laboratories. It is an oil-cooled 1½-ton iron-core electromagnet wound with 6000 turns of square copper wire and tipped with a special magnetic alloy.

The magnet, 5 ft. long and 2½ ft. high, has adjustable poles so that specimens from 1½" to 12" may be attracted and is capable of exerting a concentrated 4,000-lb. pull—a force strong enough to make possible new studies in magnetism. One secret of the high magnetism produced is the special alloy tips. This alloy was developed by the Westinghouse Research Laboratories to give more magnetic energy than ordinary iron.

The variation in the gap between poles is accomplished by the use of adjustable tapered pole-pieces. This feature adds immensely to the versatility of the magnet. Cooling the 28,000-watt magnet is accomplished by a flow of 17 gallons of oil per minute through the coils.

The new magnet can be used in the production of tiny permanent magnets for aircraft instruments; as a fundamental research tool for the study of the relationship between the crystal structure of metals and their magnetic properties, and as an aid in the design of cyclotrons.

Constant Speed from a Variable-speed Motor

EAST PITTSBURGH, Penna.—There seems to be a certain perversity about engineering needs. Sometimes a variable speed is desired from a basically constant-speed machine. Then again a constant speed is sought from one that operates at changing speeds. Worthy of note is one ingenious method developed by Westinghouse for obtaining from a d-c. motor a speed held closely constant regardless of normal changes in load, voltage and temperature.

On the motor-shaft extension is a smooth drum. Surrounding this drum is a cage with lengthwise slots. Resting in these slots and riding on the motor drum are carbon blocks, held in position by garter springs. The cage is connected to the driven load. The motor is arranged so that at all times its speed is above that desired, but the blocks and springs are so adjusted that, at the correct speed, the centrifugal forces lighten the pressure of the springs and the carbons slip just the right amount on the motor cylinder.

The resulting speed regulation is remarkably constant. On a motor-generator set serving a torquemeter, the 400-cycle output is held within one cycle for motor speed changes from 8400 to 11,000 r.p.m. The output of the set is entirely an instrument load and does not vary widely. At constant load the variation for all atmospheric conditions of temperature, altitude, and humidity is approximately 0.25%.

The device is flat compensated for wear but tests show barely measurable change in the surface of the friction members in 2000 hours of operation. These carbons however must be carefully chosen, for constancy of friction characteristics with temperature and durability at high altitude.

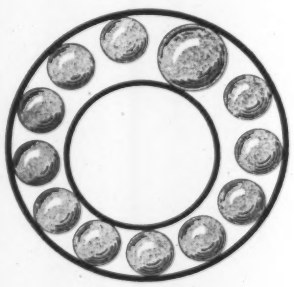
This type of drive is not intended for use with large outputs (it has been built in sizes up to one kw.), nor for wide load variations. A 50% change in load produces a speed change of a little more than 1%.

Automatic Ball-grading Machine

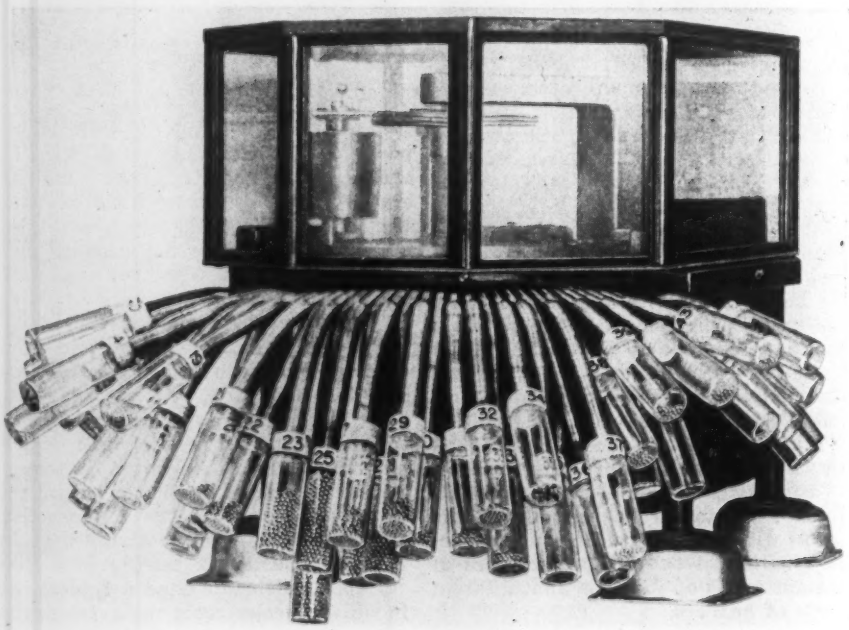
CHICAGO. — Production-line precision has reached one of its highest stages of development in the unique ball-grading machine designed by Bell & Howell engineers and used at the company's Lincolnwood plant. In sorting and grading the tiny steel balls used in bearings on B&H movie projectors, the machine is accurate to within 0.00002" (2/100,000 inch).

Although the balls are graded to close tolerances before delivery to Bell & Howell, company engineers insist on even closer measurements in order to effect maximum uniformity among all the balls used in any one bearing assembly. The logic of this is apparent when it is considered that one oversized ball in a bearing will carry most of the operating load and thus will seriously damage the bearing. This is shown in the diagram, which is an exaggerated cross-section of a ball bearing where one oversized ball gets most of the load, wears out rapidly and throws the entire bearing off center.

Before being placed in the grading machine, each group of balls undergoes four successive cleaning baths, to remove any trace of oil or other foreign matter which might cause erroneous measurement. Upon being placed in the characteristics with temperature and sorted, the balls are guided into numbered chutes, the ends of which are connected to glass vials by means of



flexible tubes. The various vials are labeled and their contents are kept separate, so that only balls of the same size are used in assembling any one bearing. Following grading, the balls are re-lubricated with high-grade acid-free oil, and the vials then are sealed and marked with the size numbers.



"One-man" Wheel Balancer

CHICAGO.—A wheel balancer with which one man can determine and correct both static and dynamic unbalance —without removing the wheels from the vehicle and in less than ten minutes per wheel — has been announced by Stewart-Warner Corp. which, during the war, was one of the largest producers of electronic devices for the armed services.

Three features were pointed out by Stewart-Warner Corp. which, during netic pick-up unit, attached to a fixed part in relation to and adjacent to the wheel. Sensitive to vibration amplitudes as small as 0.002", this pick-up unit transmits current impulses to an indicating instrument and actuates (2) an electronic amplifier, similar to a four-tube radio set, which amplifies the electric energy created by the pick-up to furnish power and control (3) a stroboscopic light. This is a neon-filled tube which flashes when the car vibrates against the pick-up unit, creating a visual effect of "stopped motion." It shows the operator the exact spot at which the wheel is out of balance and opposite which corrective weights must be placed to bring it into balance. (See Fig. 1)

In balancing front wheels (Fig. 2) the operator jacks up the front of the vehicle about two inches and places a "wheel spinner," with a high-speed 110-volt a-c. motor against the tire tread of one wheel. (An accessory wheel speed indicator, the shaft of which is held against the hub cap of the wheel, registers speeds up to 90 m.h.p., reading both clockwise and counter-clockwise.)

In balancing rear wheels, a jack is placed under the center of the rear axle housing. A wooden rear-wheel block, with steel plate, is placed under one wheel to prevent it from turning while the other wheel is being balanced. The vehicle's own engine power is used to rotate the wheel being balanced. Rotative speed is regulated by a remote control accelerator depressor with an eight-foot cable, making it unnecessary for the operator to leave his position beside the wheel. (See Fig. 3.)

In balancing wheels in their natural operating positions, the device balances, as one unit, the tire, tube, wheel, hub cap, hub and brake drum. In addition to measuring balance, it detects existence of any defective, worn or out-of-adjustment parts which cannot be corrected by conventional balancing of the wheel itself. Thus it detects a dry bearing or loose bearing, dragging brakes, tire distortion at high speeds, worn or loose wheel suspension and other potential repair-bill dangers.

Availability of this new instrumental method is expected to make wheel-balancing a regular and more widely available service for car and truck owners, in the same category of preventive service as periodic lubrication.

Fig. 1

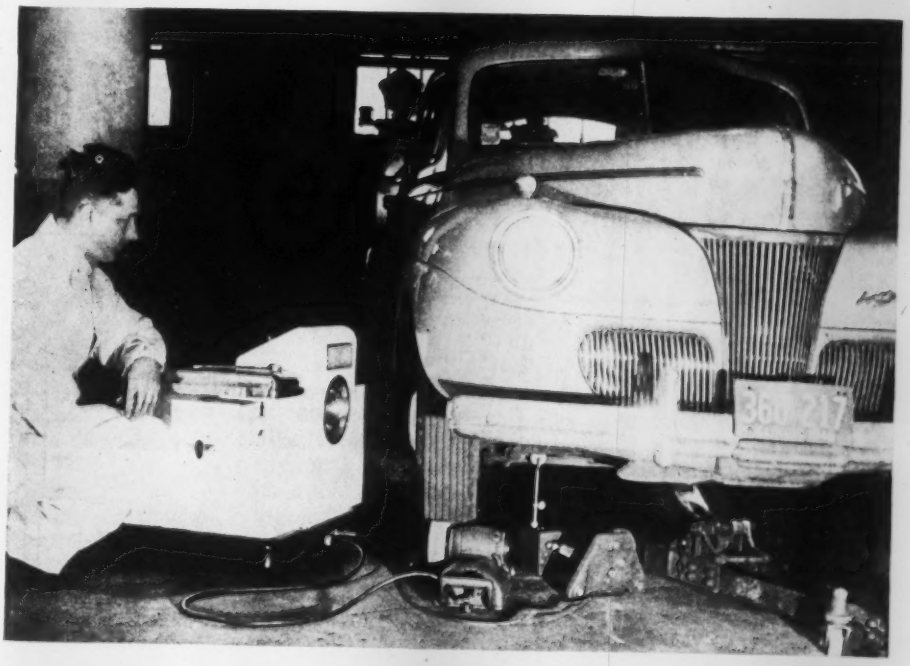


Fig. 2

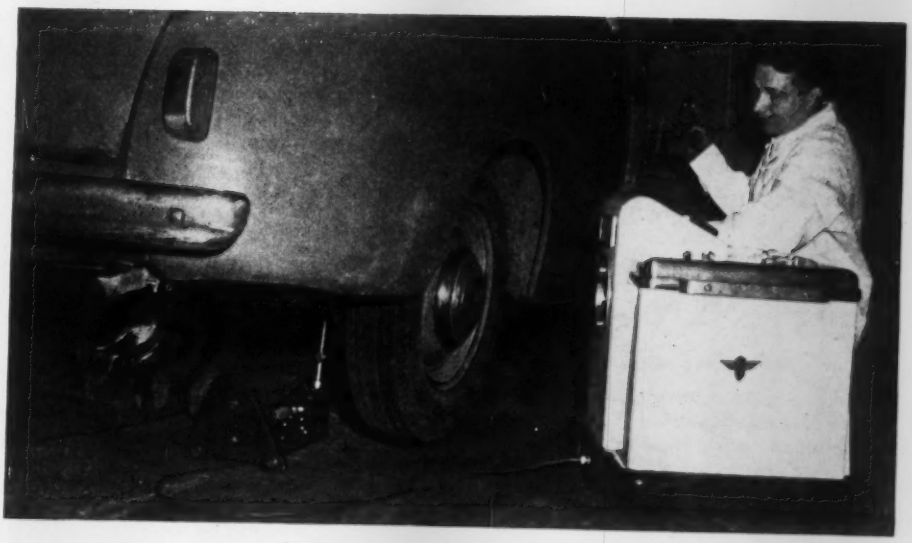


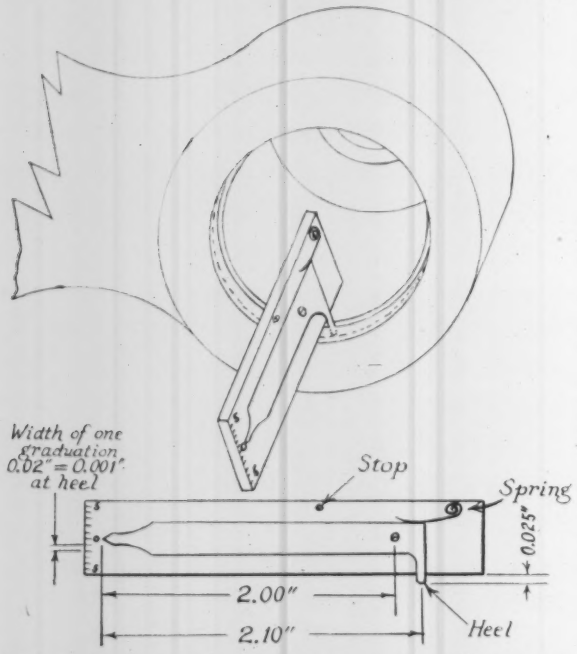
Fig. 3

SHOP KINKS

Gage for Checking Depth of Undercut

By MARTIN RHOADS, Baltimore, Md.

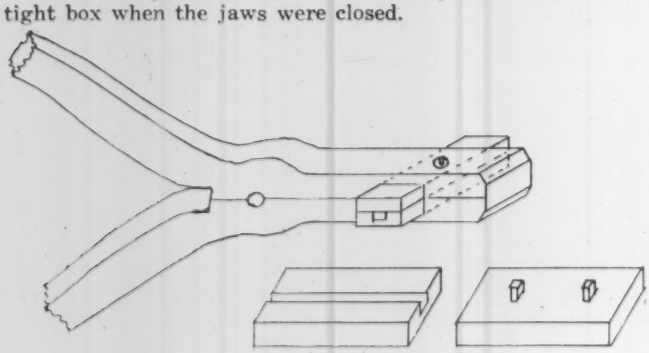
IN many instances, bearing bores in aircraft fittings had to be concentric with the retainer groove and the depth of the groove was held to close tolerances. Checking the operation was quite expensive with standard instruments. Since most of the fittings called for depths of 0.025", the simple gage illustrated herewith cut the cost of checking this operation to practically nil. It can be made from brass or aluminum.



Small-bar Mold

By G. EVERETT MARSH, Washington, D. C.

THE production of small bars of brittle metals offers considerable difficulty when routine procedures are followed. A simple, speedy and highly satisfactory method was devised for making 1 × 1 mm. bars of bismuth and antimony. A channel 1 × 1 mm. was cut the entire length of a plate of steel, 10 × 10 × 4 mm.; a second blank was provided with two 1 × 1 × 1 mm. pins 5 mm. apart. When the two pieces were placed together the space in the groove between the pins formed a cavity 1 × 1 × 5 mm. The two pieces were attached to the jaws of a small pair of pliers, the jaws being suitably cut away to permit the plates to be inserted into position and to close evenly and thus make a tight box when the jaws were closed.



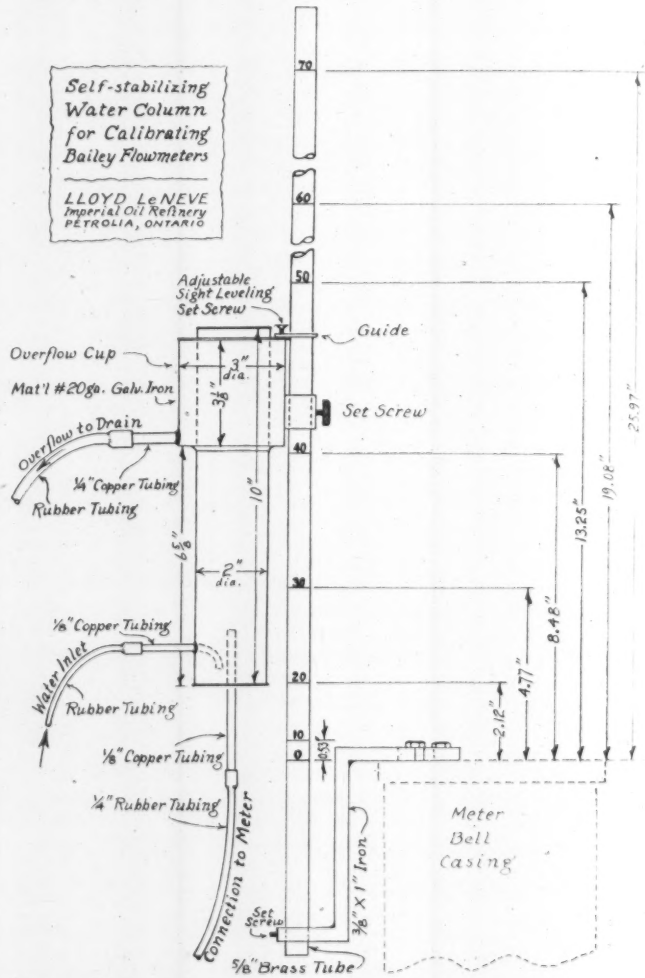
Immersing the open jaws in the molten metal and then closing them fills the box with metal; on setting the pliers aside a few minutes to cool, a bar 1 × 1 × 5 mm. may be removed from the mold without difficulty. As the metal expands on cooling, a slight divergence of the sides of the box may be necessary to facilitate the removal of larger bars. The bars have a smooth surface and require no finishing operation; they are all exactly the same size and their production is accomplished without loss of metal.

Special Water Column for Calibrating Flowmeters at Low Heads

By LLOYD LeNEVE, Imperial Oil Refinery, Petrolia, Ontario

WHILE using a regular type Bailey test set in calibrating Bailey 53" and 120" meters (Types C5 and C35), it was found that the water meniscus, with its crescent point upward, had a depth of 0.05" which, if read wrongly at a 10% test, would give an error of 0.05" at a bell displacement of 0.51", or an error of 10% at the most critical measurement for determining the correct amount of extra weights to be added to the Ledoux Bell.

Eliminating this fault was difficult because this error depended entirely on the way the operator read the height of water head.



To overcome this, a self-stabilizing water column, with its meniscus having its tips pointing downward, was designed. A constant flow of water keeps the water in the bottle at a fixed height and with the meniscus tips pointing downward a clear view of the top of the water head is given and a sighting screw is then set in the same plane as the top of the water head.

In operation, the water is turned on and the sighting

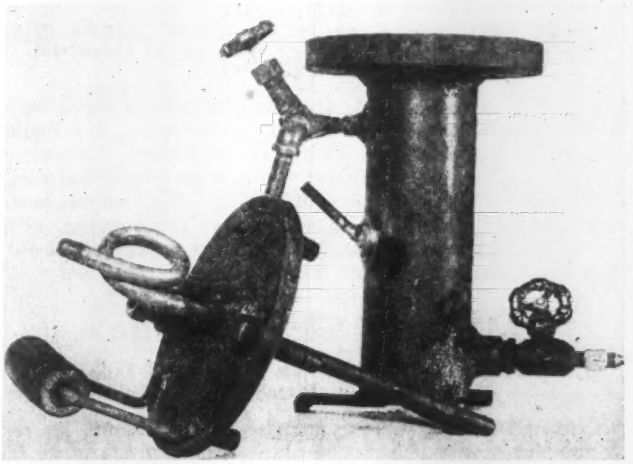
screw is lined up with the top of the water head. The water bottle is moved up or down and the sighting screw set opposite the desired reading on the scale. The water column automatically stabilizes itself at the correct water head and it is impossible to have any deviation in reading the height of the water head.

The Self-stabilizer has been designed to facilitate accuracy, ease of operation, and economy of man-hours on a calibration test.

Field Checking of Thermometers

By JOHN J. KIRKPATRICK, Instrument Engineer, Koppers Co., Inc., Pittsburgh, Penna.

IN a chemical refining plant, whose process handles inflammable liquids or gases, an ever-present problem is the field checking of thermometers at temperatures above 100°C. Ice water at 0°C., intermediate-temperature service water, and water boiled with live steam, have usually sufficed for a three-point check of thermometers in the field—



on the assumption that a three-point check guarantees accuracy over full range.

At our plant, where butadiene and styrene are produced, we began to observe some astonishing readings at temperatures in excess of 100°C. Temperatures based on pressure-temperature relations of known products were obviously low. To make things worse, these temperatures would suddenly correct themselves without any change in the product or any change in the pressure reading. Though we subsequently found the cause for these mysteries, we felt that it was mandatory to check the thermometer for one point near the expected operating temperature. To avoid bringing thermal systems into the shop we had to develop some method that did not use fire or electricity. We finally developed and built a thermometer test pot which proved so satisfactory that we built seven more for use throughout the plant, even eliminating our electrically-heated bath in the shop and switching over entirely to the new test pot.

Knowing that throughout the distillation area we never used a temperature in excess of the saturation temperature of the steam used in reboilers, heat exchangers, preheaters, etc., we decided to use high-pressure steam to produce the desired temperatures. Our first attempt was to put a copper coil in an oil bath. This equipment was heavy and clumsy; heat radiation from the bath made it impossible to maintain steam saturation temperature; and it was difficult to agitate the bath properly to insure even temperatures.

Still in favor of the high-pressure steam idea, we developed the bath shown in the accompanying photographs, which effectively cured our problems. It consists of a 12" piece of 3" pipe with one end welded shut and the other end flanged. In the companion blind flange we welded a coupling and installed one of our standardized thermometer wells. As refinements we added a pig-tail for a pressure gage connection and a carrying handle. Through the side of the 3" pipe we put a thermometer test well made of thin-wall steel tubing. This well lies close beside the thermometer well to assure temperature equality. In use it is filled with mercury or oil to increase the heat transfer. In the bottom of the 3" pipe we inserted a sparger made of a short piece of ⅜" pipe closed at one end and having three ⅛" holes drilled in its bottom. A needle valve controls the flow of steam to the sparger. At the top of the 3" pipe, just below the flange, we placed a nipple and a needle valve to be used for draining condensate and for back-pressuring the pot.

In operation we connect a steam hose to the sparger, open the bleed valve at the top, and crack the sparger valve. After letting the steam flow through a while to expel air and build up condensate, we install the bulb of the thermometer to be tested and insert the test thermometer. Now

both thermometers should read 100°C. (or near that point, depending on atmospheric pressure). Then, by shutting off the outlet valve a bit, we can raise the temperature to some new point. By proper handling of the inlet and outlet valves, any temperature up to the saturation temperature of the steam can quickly and easily be obtained.

Some of the advantages: (1) There is constant agitation of the bath, since the water is always boiling at the saturation temperature produced by the back pressure. (2) The temperature may be changed so rapidly that the pot will go from 100°C. to saturation temperature in less than two minutes. (3) The device is convenient to use, for it can be carried to the location of the thermometer bulb and hooked up with steam hose, obviating the need of taking down thermometer tubing.

The test pot illustrated was expressly made for one size of bulb, but we have built another that has an oil-filled well that will take any bulb we use. Many modifications are possible. In fact we have gone so far in the use of this method as to make a heating bath that enables operators to run their own test distillations without leaving the operating floor.

Experimental Form for Delicate Coils

By WALTER SCHMIEDESKAMP, Livingston, N. J.

IN making small coils experimentally, such as are used for d'Arsonval instruments and phonographic and other small pick-up devices, the greatest difficulty usually encountered is in getting these coils off the winding form after they are wound and lacquered. This is especially true of self-supporting coils. There is a material known as Cerrobend which is a Woods metal type of alloy melting at about

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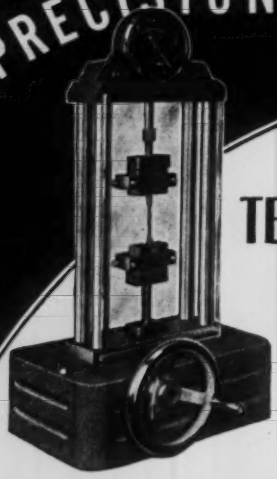

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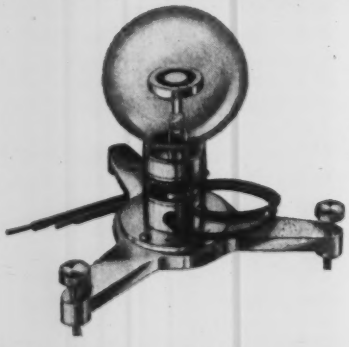

Eppley pyrheliometers are in use measuring solar radiation at fourteen out of eighteen weather stations in the United States, nine of these stations being under the direction of the United States Weather Bureau.

To industry they are an invaluable aid in the testing of paints, finishes, textiles, etc. for sunfastness.

Bulletin No. 2 On Request

THE EPPLEY LABORATORY, INC.
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78°C., commonly found in experimental instrument shops. If the coil form is machined out of this material, the coil may be wound in it, lacquered and dried; and the Woods metal melted out by placing the coil in a warm oven or hot water. This saves damage to the coil which might otherwise occur in stripping it from the rigid form. The meltable form is easy, certain, a time-saver, and capable of handling the most difficult coil shapes.

Gathering Spilled Mercury

By LESTER F. BOSS, Mellon Institute of Industrial Research, Pittsburgh

SPILLED mercury may be easily gathered by sprinkling fine dry sand over the area and then brushing the mercury and sand into a dust pan. Upon shaking the dust pan (or other container) into which the mixture has been poured, it will be observed that the mercury has collected under the sand. It is then a simple matter to pour out the mercury.

Decantation

By LESTER F. BOSS, Mellon Institute of Industrial Research, Pittsburgh

WHEN pouring liquids from full containers which have a small opening near one side of the top, the liquid frequently "runs back!" This may be almost completely avoided by tilting the container with the opening uppermost. The container will then have to be tilted to an almost horizontal position before the liquid reaches the opening, with the result that when the liquid does flow it will run away from the opening.

Method of Cleaning Wire

By LESTER F. BOSS, Mellon Institute of Industrial Research, Pittsburgh

SCRAPING wire, for the purpose of brightening, or removing enamel, insulation or corrosion, preparatory to soldering or making connections, may be greatly facilitated by using the teeth of a hack saw blade. This method saves time and is particularly useful on fine stranded wire when a fine jeweler's saw blade is used.

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on instrument testing, repair, installing, etc.

This is to remind our readers that *Instruments* pays $5 (or more*) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication.

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1. Type double-spaced on one side of paper. Author's name and address at top of first page (envelopes get lost!)
2. Diagrams must be in black ink (no blueprints). Lettering (if not made with aid of machine) may be soft-pencil, to be inked-in by *Instruments*.
3. Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).
4. Each contribution to describe ONE method or device. An author may send as many as he likes.
5. Mail all entries to Shop Kinks Dep't of *Instruments*, 1121 Wolfendale St., Pittsburgh 12, Pa.

*Five dollars is for textual entry accepted: a greater minimum is paid for accepted entries including drawings and photographs.

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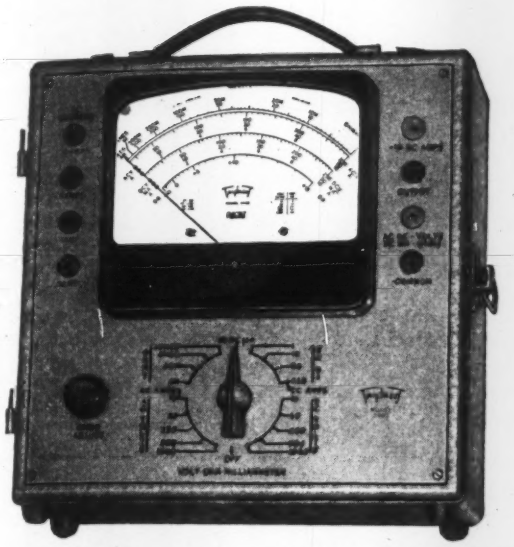

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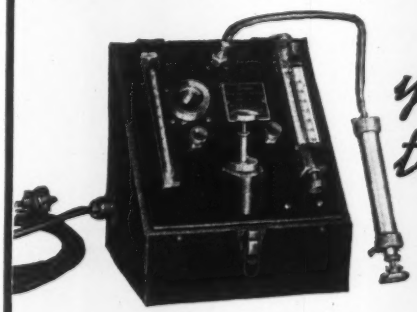

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X. VACUUM GAGES

Numerous gages for measuring various degrees of vacuum have been developed, but no single gage has been found which can be classed as a universal practical gage over the entire range of low pressures. Each has some distinct disadvantage, either in construction details or auxiliary equipment which must be used with the gage. Usually it is best to adopt the gage which is most suited for the particular pressures required. It is sometimes necessary to use several gages on a single system. Each gage can then be used in its recommended range and with such a combination it is possible to attain greater accuracy in pressure measurements.

Vacuum gages can be divided into two types or classes. The first type operates on the principle of comparing the unknown pressure with a known pressure by the difference in liquid levels or by a type of Bourdon tube which is deflected from the null point by the pressure within the tube. The second class depends on the number of gas molecules present in the gage and their respective properties.

Simple Manometers

The simplest vacuum or pressure gage is the manometer which consists of a U-shaped tube containing a liquid of known density and so arranged that the difference in level of the liquid may be observed. The space above the liquid on one side may be evacuated or exposed to a chamber containing gas at a known pressure. The pressure in the system attached to the other side of the manometer is then read as being greater or less than the known pressure on the other side, by a pressure equivalent to the difference in height of the liquid in both legs. A closed-end manometer is useful when pressures in the range of 1 to 20 mm. of mercury are to be read. They occupy little space and use small amount of mercury. In almost all cases a constriction in the tubing at the manometer bend is necessary for preventing rapid liquid surges when the pressure on one side is suddenly changed.

While in principle the manometer is very simple, there are certain principles which must be considered in its construction, especially if the manometer is used for accurate pressure readings. The rise or depression of liquids in small bore tubes is given by the following equation:

$$h = \frac{\gamma\, 2 \cos \Theta}{r\, g\, d}$$

where γ=surface tension of liquid in dynes/cm.;
r=radius of the tube in cm.;
h=rise or depression of liquid in tube in cm.;
g=acceleration due to gravity cm./sec.^{2};
d=density of liquid in gm./cm.^{3};
Θ=angle of wetting of liquid with side wall.
Θ=0° for complete wetting;
Θ=180° for non-wetting.

Water and mercury can be considered as extreme cases of manometer liquids. Their respective surface tensions are 72 and 465 respectively at 20°C. Substituting these values in the above equation along with the proper density and gravity constants and assuming complete wetting of the surface in the case of water and complete non-wetting in the case of mercury, the capillary rise or depression for various tube radii given in Table 18 are obtained.

TABLE 18
EFFECT OF TUBE RADII ON CAPILLARY RISE

Radius of Tube mm.	*Liquid Rise in mm.* *Mercury*	*Water*
1.0	—6.8	1.47
5.0	—1.36	0.29
10.0	—0.68	0.15
20.0	—0.34	0.08

The negative values in Table 18 designate a depression. The manometer must therefore be constructed of tubing with the same diameter. If the two legs are of unequal diameters, not only will there be a difference in height due to pressure but also due to capillary effects.

The angle of wetting is another factor which must be considered. In the calculation of the data given in Table 18, it

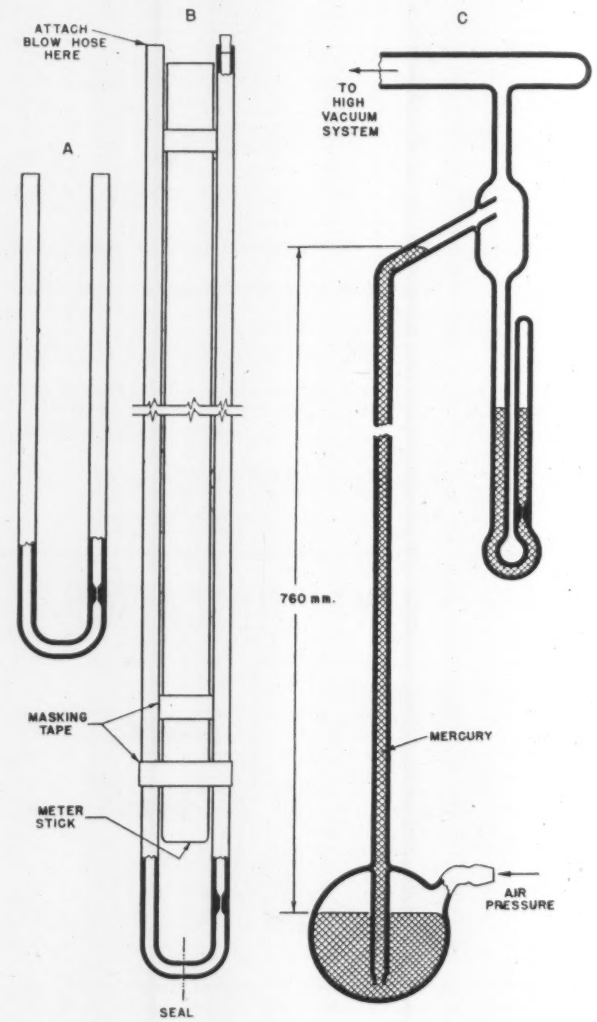

Fig. 122

was assumed that the wetting angle of mercury and water was 180° and 0° respectively. Fortunately in most cases this is not true and therefore the capillary effects are less by the factor, cosine Θ. Even if both sides of the manometer are the same diameter, there can be a difference in the angle of wetting in the two legs caused by moisture or dirt on the surface of the glass. This will give a difference in zero point in the two manometer tubes. To minimize this effect the manometer tubing should be as large as possible. Tubing with diameters of 12 to 15 mm. is recommended when differences of ± 0.1 mm. of mercury are to be read.

The manometer is limited for measuring pressures only by the strength of the confining glass tubes. For vacuum measurements, it is limited by the operator's ability to accurately measure the difference in height between liquid levels. For most mercury manometers even with level-reading in-

struments such as a cathetometer, pressures below 2 mm. are subject to considerable uncertainty.

The construction of the short simple U-tube manometer is not difficult. A section of glass is thoroughly cleaned. A portion near the center of the tube section is fused and constricted by rotating it in the burner flame. The constricted section should not be over 1 cm. in length and the outside diameter of the constricted section should be identical with the original tube. The glass tube is then bent into a U-shape as illustrated in Fig. 122A. The constriction in the manometer should be adjacent the bend. One leg of the manometer is closed.

Long U-tube manometers are convenient when a pressure range of 760 to 1 mm. of mercury is required. The fabrication of such manometers is not difficult if the two manometer arms are taped to a meter stick after the constriction and the tube ends are shaped as shown in Fig. 122B. The tubes are sealed together by fusing the ends of the two tubes. A blowing tube is fastened to the one open end while the other is stoppered.

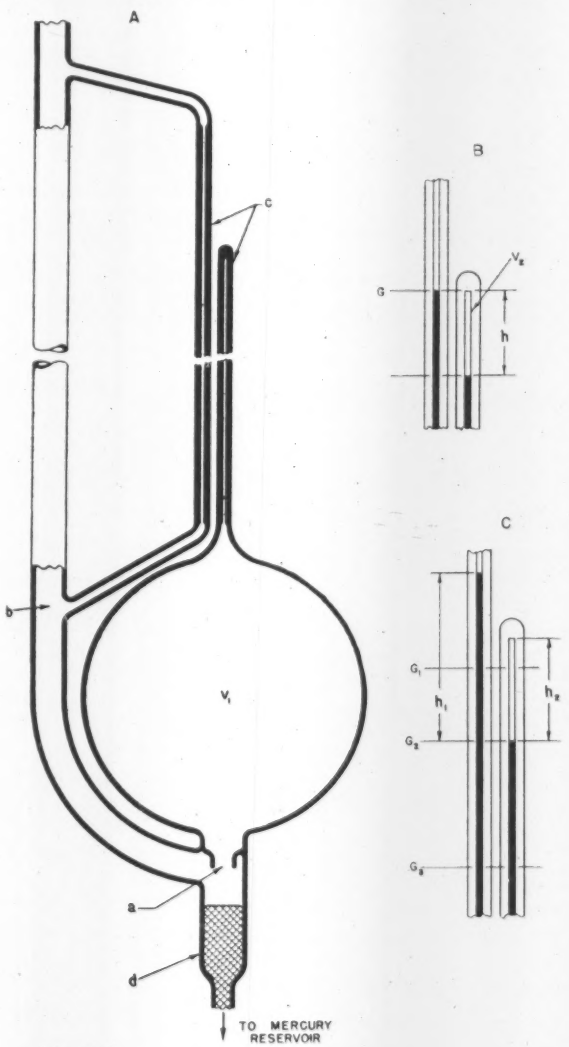

Fig. 123

Closed-end manometers are frequently used as approximate vacuum indicators in vacuum systems or for vacuum indicators where the accuracy of 10% is sufficient. These manometers usually are about 6" in length with the closed end completely evacuated. The production of these manometers is as described above. The manometers are filled with mercury by various methods. A practical method of filling several at one time is illustrated in Fig. 122C. A mercury filling tube 760mm. in length is ring-sealed into a large mercury reservoir. The opposite end is ring-sealed into a small bulb. Two outlets of the bulb are sealed to the open end of the manometer and the manifold of the vacuum system. Triple-distilled mercury is poured into the clean reservoir. The vacuum pumps are started and after a vacuum of the order of 10^{-6}mm. of mercury is obtained, the manometer is heated with a torch. After the manometer is properly degassed and a vacuum better than 10^{-6}mm. of mercury is obtained, the mercury in the reservoir is forced into the manometer by applying air pressure to the reservoir side tube. Several manometer filling units can be sealed to the same vacuum manifold.

McLeod Gages

The McLeod[1] gage was among the first gages developed for measuring vacua and is still used extensively as a laboratory instrument. It is, in general, simple in construction and operation and, when properly calibrated, it is reliable within certain pressure ranges which will be discussed later. Moveover, gages can be made to read pressures as high as 50 and as low as 10^{-5}mm. of mercury.

The principle of the gage is that of compression of a known volume of gas at an unknown pressure to a smaller volume. The pressure at the smaller volume can be determined by difference in height of a mercury column. Assuming Boyle's law we can then calculate the original unknown pressure by the equation:

$$P_1 = \frac{P_2 V_2}{V_1}$$

where P_1 = unknown pressure;
V_1 = initial volume before compression;
P_2 = final pressure;
V_2 = final compressed volume.

A simple McLeod gage is illustrated in Fig. 123A. It is operated by causing the mercury to rise and enter the bulb V_1 at a. The gas within the bulb and capillary c which is sealed to bulb V_1 is cut off from the rest of the system when the mercury passes through the ring at a. The gas in V_1 is compressed by the mercury until the mercury column in the outer capillary is coincident with the gage mark G which also coincides with the end of the closed capillary, Fig. 123B, or the mercury in the closed capillary becomes coincident with an arbitrary mark G as illustrated in Fig. 123C. In either case V_2 can be calculated from the length and radius of the capillary and P_2 is directly the height of the mercury column in the open capillary. V_1 is known and therefore the pressure P_1 can easily be calculated.

McLeod Gage Dimensions

For vacua in the range of 10^{-4} to 10^{-5}mm. of mercury, V_1 usually is 200 to 300cc. in volume and the capillary diameter is approximately 0.5 mm. If a larger volume is used, the weight of mercury becomes excessive and an increase of several times V_1 gives little increase in gage sensitivity. However, if smaller capillary tubes, below 0.5 mm., are used, the mercury column separates when mercury is lowered in the gage. A gage with the dimensions given above has a sensitivity of $10^{-6} \times h^2$ mm. of mercury when read as illustrated in Fig. 123B. With a capillary 0.5 mm. in diameter and 200 mm. long pressures up to 0.04 mm. of mercury can be read. When higher pressures must be measured, 35 mm., a smaller ratio of V_1 and V_2 is required. A volume of V_1 of 8 cc. and a capillary 200 mm. long and 3 mm. in diameter will give measurements up to 35 mm. of mercury by the method illustrated in Fig. 123B. Pressures up to 50 mm. of mercury can be read on the gage by the method illustrated in Fig. 123C.

Calibration of McLeod Gages

The calibration of the McLeod gage may be either a simple or an elaborate operation depending on the subsequent use of the instrument. It should be pointed out that the accuracy of the McLeod gage is of the order of 1% even though a perfect calibration is made. Reasons for this percentage error when absolute pressures are measured will be discussed later.

The first step in calibrating parts of the gage is to choose

several 60-cm. lengths of capillary tubing with approximately the correct bore. These capillary tubes are carefully cleaned and dried. A small amount of clean mercury is drawn up into the capillary tube and the length of this section of mercury is measured as accurately as possible. The length and position of the mercury are recorded. The thread is then moved to the adjacent portion of the capillary tube and the length and position are again recorded. This process is repeated, Fig. 124A, until the entire length of the

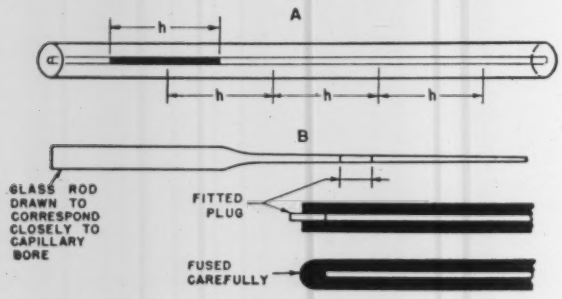

Fig. 124

tube has been covered. By this procedure the uniformity of the bore can be determined. A plot of mercury thread length versus position on the entire tube can be made for a graphical representation of bore uniformity. It usually is not difficult to find capillary tubes with less than 1% variation. The mercury is then carefully removed and weighed on an analytical balance. By knowing the temperature of the mercury during the measurements, weight and density, it is a simple operation to calculate the radius of the capillary or its volume per millimeter of length. Repeated calibrations with different thread lengths of mercury can be made if greater accuracy is required.

Two sections of capillary tubes are then chosen for the gage. One is closed by using the procedure illustrated in Fig. 124B. The capillary bore should be perfectly cylindrical to the end. The end is closed by first drawing a fused glass rod to a thin rod. A section of this rod with a diameter of the capillary is placed in the end of the capillary. The capillary tube is then heated at the end until the glass completely fuses. The tube section just below the end of the bore should not be deformed because of the danger of changing the volume of the capillary.

If the gage is to be used and read as illustrated in Fig. 123C, it is wise to determine the location of the gage marks indicated by *G*. The capillary is first weighed and then is filled with mercury from the closed end to each respective mark and weighed. From the mercury density a direct calculation of the volume of the capillary from the marks to the closed end can be made. The volume per length as a function of length can be plotted and, as it takes into account any variations in bore dimensions, these data are preferred, particularly when the gage is to be read in this manner.

The capillary is sealed to the bulb V_1, Fig. 123A, and the ring seal *a* at the bottom of the bulb is made as illustrated, Fig. 123A. The bulb V_1 is then filled with either mercury or water. The bulb must be filled exactly to the inverted seal or cut-off at *a*. No air pockets should be trapped in the bulb. If the calibrating liquid enters the capillary, a weight or volume correction can be made, by obtaining the volume of the particular section from the plot of volume versus position in the capillary. The amount of liquid in the bulb V_1 is then determined by weighing the liquid and with temperature measurements the volume can be obtained.

The gage is then assembled as shown in Fig. 123A. The capillary on the tube leading to the system should have a bore which conforms as near as possible to the closed capillary. A study of the graph of volume versus position of each capillary will aid in making the proper choice. One must be very careful that the volumes of the bulbs and capillary are not altered when the gage is made.

After the gage is assembled, it is mounted on a convenient rack or holder. A method of raising the mercury into the gage must be chosen. Two important factors must be considered. First, the flow must be controlled so that no rapid surge of mercury occurs as the mercury is raised, because of the danger of breaking the gage. Second, the flow must be controlled so that the mercury can be stopped exactly on the predetermined calibration mark on the gage.

There are several methods of raising mercury into the McLeod gage. Four commonly-used methods are as follows:

1. The simplest, although not necessarily the most satisfactory way of raising the mercury is by means of a mercury bulb and rubber tubing, as shown in Fig. 125A. This method is quite convenient but is not conducive to accurate setting of the mercury levels in the gage.

2. A second method is shown in Fig. 125B. In this case a full barometric leg is inserted between the cut-off of the gage and the mercury reservoir. It has its advantage in that the gage may be turned directly to the full vacuum line, thus eliminating any air that may be trapped. The

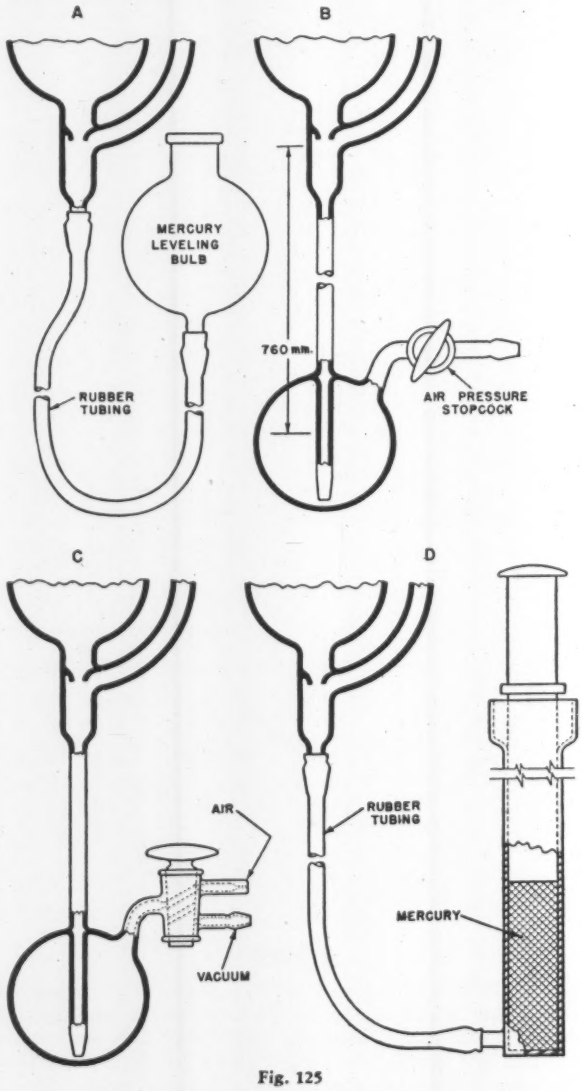

Fig. 125

barometric leg may serve also as an approximate indicator of the vacuum in the system. It has the disadvantages that the length of the gage is increased and that air pressure is required to raise the mercury into the gage.

3. The method shown in Fig. 125C is in general the most satisfactory for raising mercury into the gage. The mercury is raised by atmospheric pressure and returned to the reservoir by vacuum supplied by some auxiliary source. The rate of mercury rise can be carefully controlled by a three-way stopcock and capillary tube.

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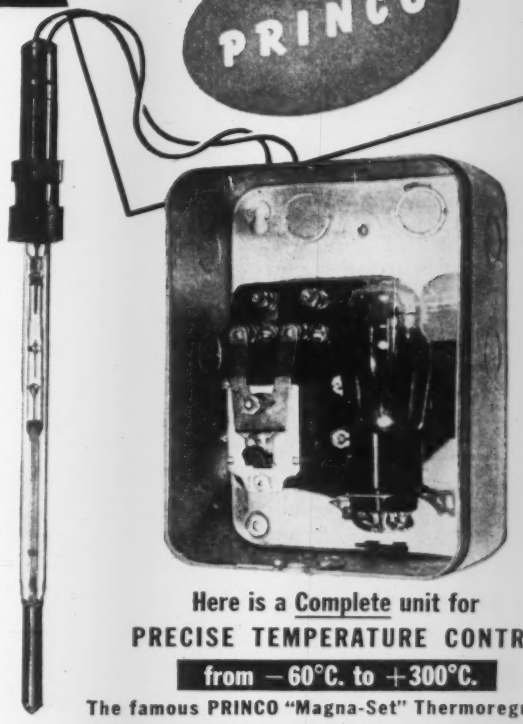

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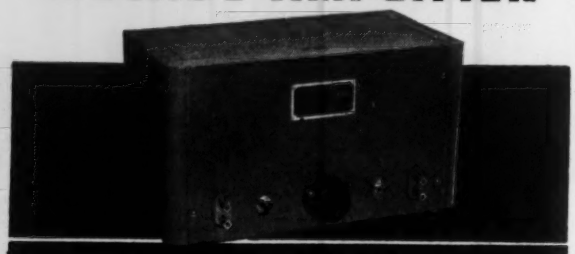

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plunger is shown in Fig. 125D. This method is better than the first discussed above because it is quite simple to attach a simple ratchet or adjusting screw arrangement to control the mercury rise. The plunger and case are made of metal that will not amalgamate.

Methods of Reading the McLeod Gage

There are two methods of reading the McLeod gage. The first is illustrated in Fig. 123B. In this case the mercury in the open capillary is raised until it is just even with the end of the bore of the closed capillary tube. To get the pressure of the gas in the system one needs only to read the height and substitute in the following formula, which is derived by assuming the validity of Boyle's law:

$$P_1 = \frac{\pi r^2 \, h \, h}{V_1} \qquad (3)$$

where V_1 = initial volume;
h = difference in height of mercury in the closed and open capillary;
$\pi r^2 h$ = final compressed volume

Equating

$$K = \frac{\pi r^2}{V_1}$$

we have

$$P_1 = K h^2 \qquad (4)$$

A metric scale may be placed behind the two capillaries. The height is read directly and the pressure P_1 is then calculated for every reading. When only approximate pressure readings are required, a scale can be placed behind the capillaries which will allow one to read the pressure directly. This scale is prepared by calculating h for various unit pressures as 1, 2, 5 and 10×10^{-5}, 1, 2, 5, and 10×10^{-4}, etc. A scale of this type is illustrated in Fig. 126.

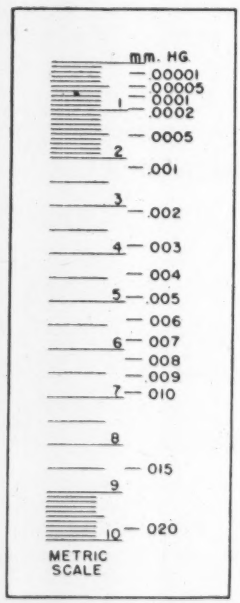

Fig. 126

The second method of reading the gage is shown in Fig. 123C. Here the mercury is raised until it is even with some arbitrary gage mark G_2. The pressure is then calculated as follows:

$$P_1 = \frac{\pi r^2 h_2 \, h_1}{V_1} \qquad (5)$$

where h_1 = height of mercury in the side capillary;
h_2 = length of compressed gas in the closed capillary.

Since the same gage mark is used for a number of readings the formula can be changed to:

$$P_1 = \frac{K_2 \, h_1}{} \qquad (6)$$

where

$$K_2 = \frac{\pi r^2 h_2}{V_1}$$

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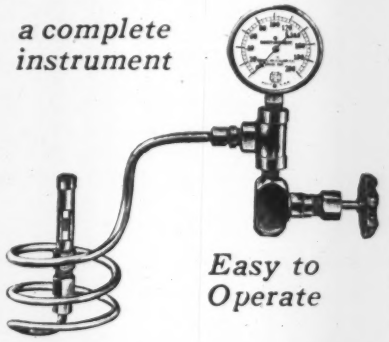

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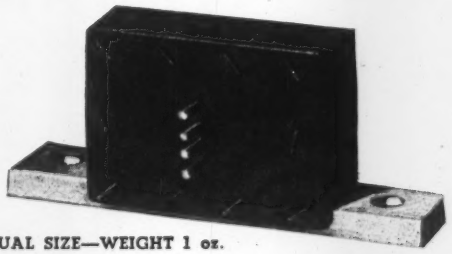

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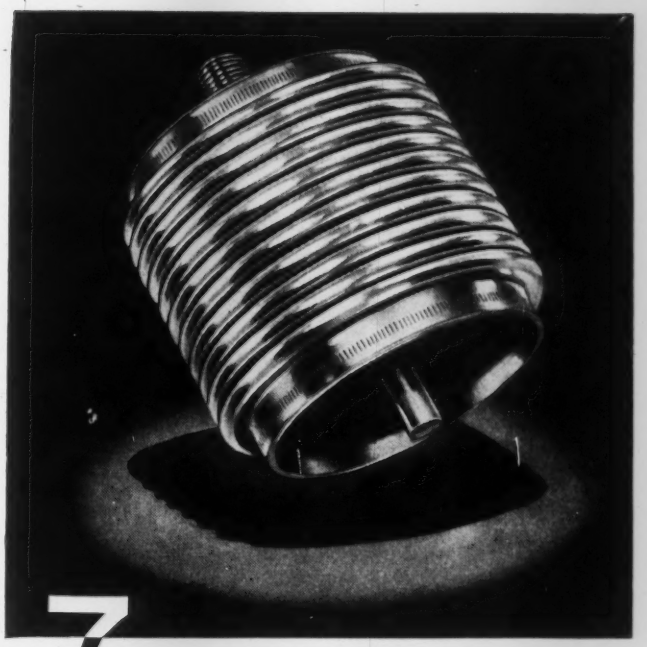

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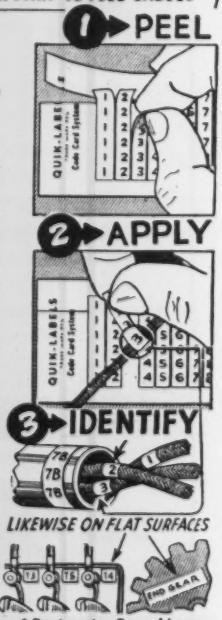

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The original pressure P_1 is thus directly proportional to the height of mercury in the side arm. There is a definite advantage of reading a gage in this manner because a number of gage marks may be used for various pressure ranges. The height of the gas column in the closed capillary h_2 can be so selected that the constant K_2 may be in some units of 10^{-x}. In other words the height of mercury in the outside tube need be multiplied by 10^{-3} or 10^{-2}, etc. to obtain P_1 directly.

The equations which have been discussed thus far are valid only for simple McLeod gages where P_1 is less than 0.1 mm. of mercury. If P_1 is not negligibly small, the equation for calculating pressure by the gage is:

$$P_1 = \frac{\pi r^2 h}{V_1}(h + P_1) \tag{7}$$

$$P_1 = K_3 h^2 + P_1 K_3 h \quad \text{where } K_3 = \frac{\pi r^2}{V_1}$$

Solving for P_1 we have

$$P_1 = \frac{K_3 h^2}{1 - K_3 h} \tag{8}$$

If gage marks as shown in Fig. 123C are used we have from equation (7)

$$P_1 = \frac{\pi r^2 h_2}{V_1}(h_1 + P_1). \tag{9}$$

Solving for P_1 we have

$$P_1 = \frac{K_4 h_1}{1 - K_4} \quad \text{where } K_4 = \frac{\pi r^2 h_2}{V_1}$$

$$\text{or } P_1 = K_5 h_1 \quad \text{where } K_5 = \frac{K_4}{1 - K_4}. \tag{10}$$

The scale which is calibrated for the quadradic equation (8) is the square scale while the scale for equation (10) is a linear scale.

When the McLeod gage is used to measure pressure above 0.1 mm. of mercury, another factor must be considered. The system quite often is small and when pressure measurements are made, the mercury in the large side arm appreciably compresses the gas in the system beyond the gage. The gage equation then becomes

$$P_1 = \frac{\pi r^2 h}{V_1}(h + XP_1) \tag{11}$$

where X is the compression factor which will depend on the size of the system and also the height to which the mercury is raised in the side arm. When the gage is read as illustrated in Fig. 123B, the final equation is

$$P_1 = \frac{h^2}{(V_1/\pi r^2) - Xh} \tag{12}$$

Equation (12) is quite complicated but it can be used. Moreover, X must be determined experimentally. The accuracy in determining this compression factor need not be extreme as $V_1/\pi r^2$ is usually a large number compared to Xh.

In order to surmount some of the difficulties discussed above, a different type of gage design is recommended. This gage is illustrated in Fig. 127A. The capillary side arm is completely separated from the system by means of an auxiliary side tube having a mercury cut-off. When the mercury is raised in the gage and side arm, there is no external pressure equivalent to P_1 or XP_1 to be considered and the simple equations of $P_1 = Kh$ or $P_1 = K_2 h^2$ can be used. The gage can be easily made and it is not difficult to operate. It does have the disadvantage that it requires a separate line to the system. There is a little more added uncertainty in the wetting angles and capillary depressions for the gases in the gage proper may influence these factors. There should be no gases in the open-arm capillary.

McLeod Gage Installation

The gage should be cleaned and all dirt and liquids should be removed. The gage can be warmed with a small hand-

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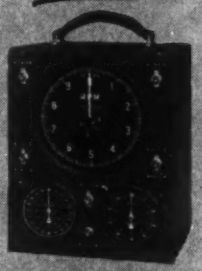

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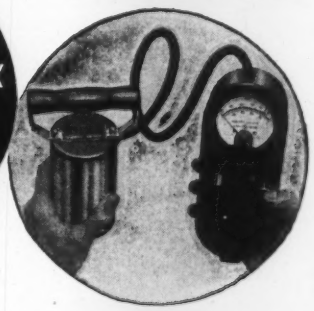

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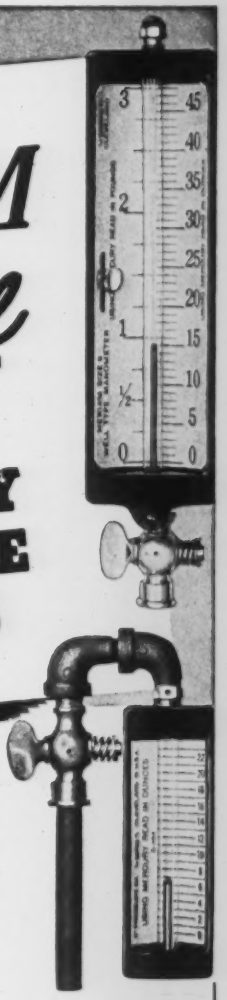

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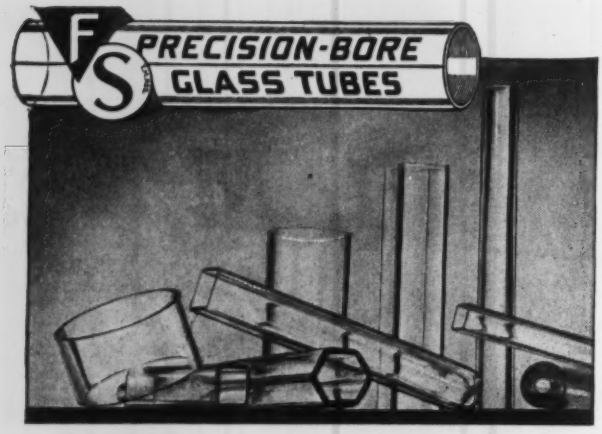

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After the gage is mounted it is well to check the following:

1. When the mercury is raised in the gage which is subjected to a vacuum of 10^{-8} mm. of mercury the two levels in the capillary tubes should be the same when the mercury flow is stopped at various points below the closed end of the capillary. It may be necessary to tap the capillaries to overcome surface effects.

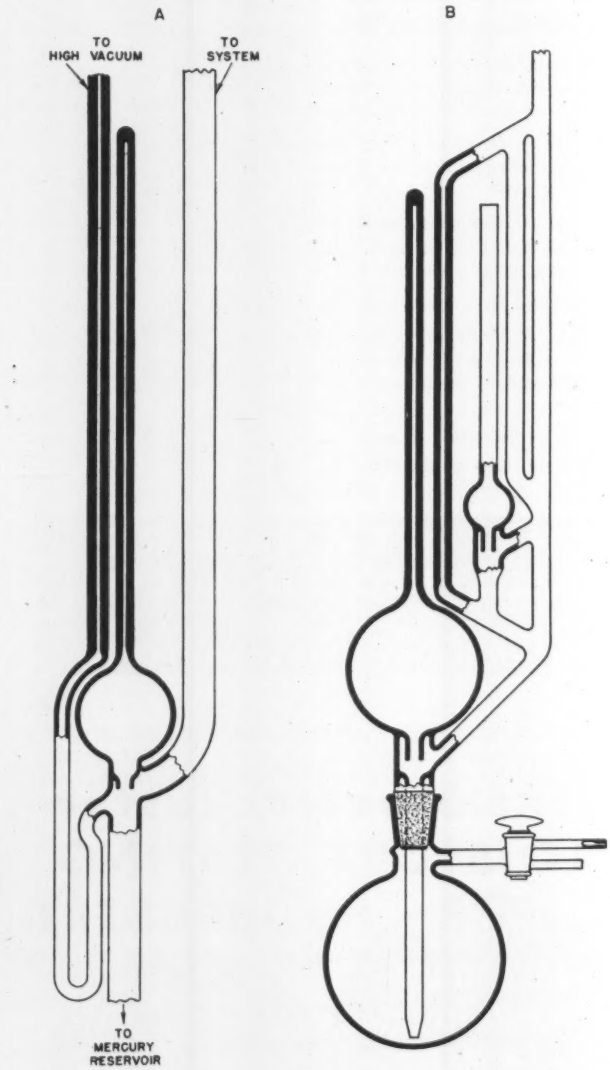


Fig. 127

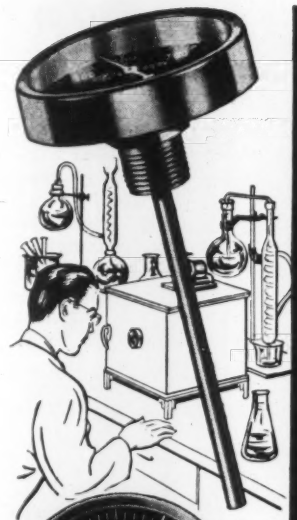
2. When the gage is read as shown in Fig. 123B, the pressure at each mark should be the same. This test is made at a pressure of about 10^{-3} mm. of mercury.

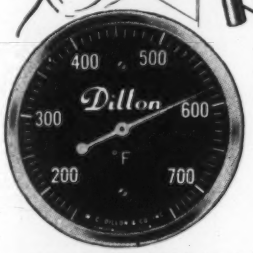
3. Measurements made on the same gas at the same pressure should all agree.

It has been pointed out in the discussion of manometers that capillary depressions are effective in a liquid such as mercury. It is therefore essential that the capillaries of the McLeod gage be tapped with the finger tips to prevent uneven effects in the two tubes.

Accuracy of the McLeod Gage

The accuracy of the McLeod gage when carefully calibrated is of the order of ± 0.5%. The capillary tubes are rarely more than 200 mm. long and the mercury columns are usually 100 to 150 mm. in length. The ability of the eye to set the mercury at a given zero mark and read heights is about ± 0.2 mm. Since there are two readings for each setting, this together with the uncertainty involved in the





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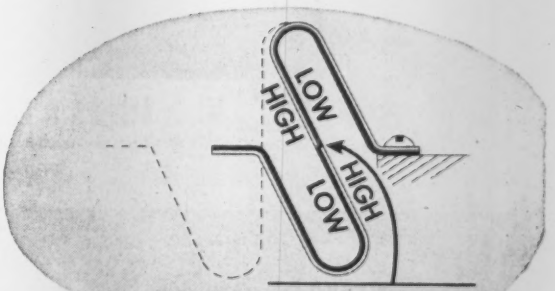

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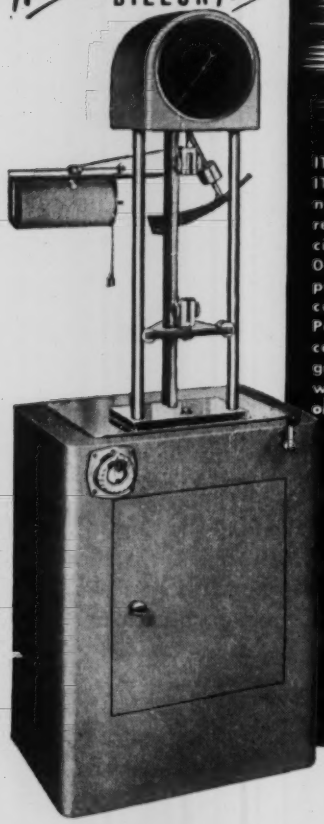

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uniformity of the capillary bore, surface tension and wetting effects, causes the error to amount to 0.5 percent.

Extending The Range of the McLeod Gage

Several different designs have been used to extend the pressure range of McLeod gages. The gage shown in Fig. 127B is made up of two gages, both of which are filled from the same mercury reservoir. It may be calibrated by either of the two methods previously described. The gage is best used for reading pressures in large systems where the compression caused by the mercury in the gage is insignificant. It should be pointed out that when the gage is used on systems of small volume the compression due to the mercury rise from the cut-off at the large bulb to the final mercury height must be considered. This gage can be made to have a range of 10^{-5} to 25 mm. of mercury.

Another gage design is illustrated in Fig. 128. The gas is compressed into a closed tube which is made up of three

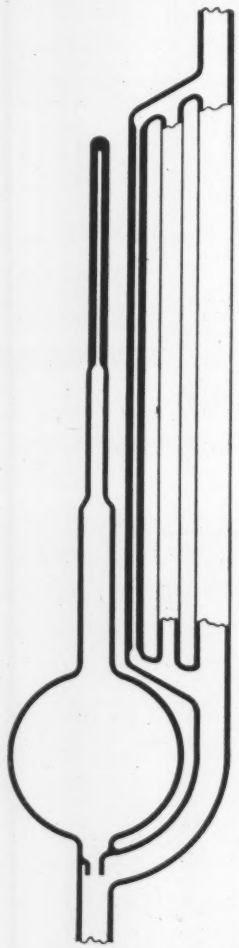

Fig. 128

different tube sizes.* The three side arms have diameters which are matched with each size of the closed tube. The gage must be calibrated and used as illustrated in Fig. 123C and the readings are made on a linear scale. The range of this gage is from 10^{-5} to 1 mm. of mercury.

In order to extend the sensitivity of the McLeod gage in the range of 10^{-4} to 10^{-6}, the use of Apeizon oil[3] is recommended as a confining liquid.

A second method[4] of increasing the sensitivity of the McLeod gage is by the use of a small Pirani or hot-wire gage in the closed end of the capillary. This gage is used after the gas is compressed in the capillary. The measured

*Editor's Note.—This multiple-chamber design with corresponding side arms is due to L. Dunoyer: *Bulletin Société Francaise de Physique*, 1923, page 246; also "La Technique du Vide" (book), 1924, pages 64-76. (English Translation "Vacuum Practice," London, 1926). For recent improvements in Dunoyer gage design see: P. Tarbès, *Le Vide*, Vol. 1, Jan. 1946, pages 9-11.—M. F. Behar.

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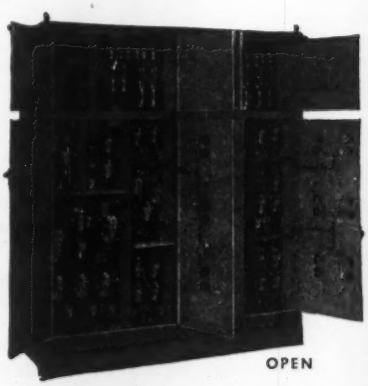

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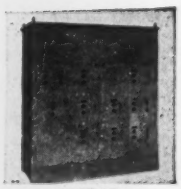

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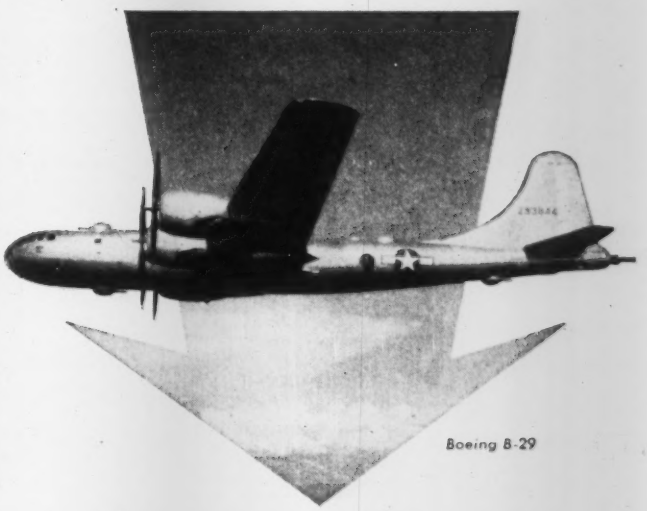

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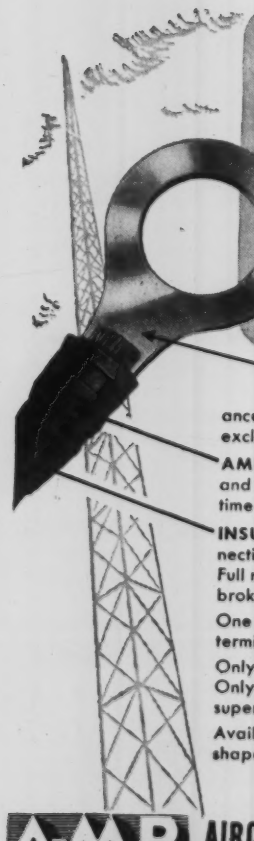

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pressure of the gas as indicated by the Pirani gage is then converted to the original unknown pressure by using the known compression ratio of the McLeod gage. The combination of these two gages can be used to read pressures of various gases but a calibration of the gage for each gas must be obtained before measurements can be made. The limit of this gage when air was the confined gas, was, according to A. H. Pfund, 1.7×10^{-7} mm. of mercury.

It should be pointed out that the McLeod gage is based on the accuracy of Boyle's Law and when this is not valid, corrections for the deviations must be made. It cannot be used for measuring the pressure of condensible gases. Precautions also must be taken when certain gases are to be used as some will attack the mercury of the gage, particularly if there is a slight trace of moisture present. Gases which have a tendency to be absorbed on glass surfaces also give incorrect pressure readings.

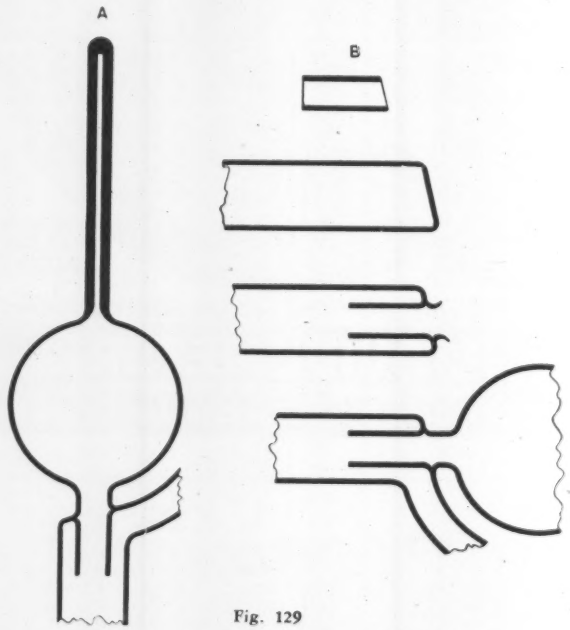


Fig. 129

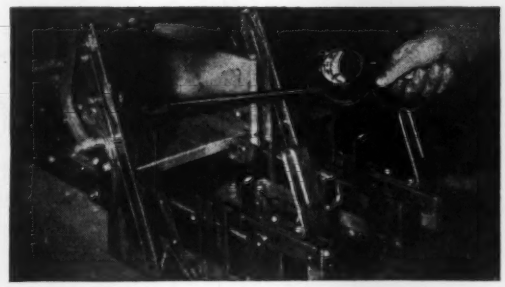
The McLeod gage frequently is used for calibrating other types of vacuum gages. When used for such purposes, it is important that no gas be trapped at the mercury cut-off. A suitable slanted ring seal below the bulb is fabricated as illustrated in Fig. 129A and is assembled as follows:

1. An 8-mm. tube is opened on a diagonal in the gas burner flame. This tube is cut 8 mm. from the diagonal cut.
2. A 16 mm. tube is closed as shown in Fig. 129B. The angle of the closure should be approximately the same as that of the 8 mm. tube.
3. The small tube is ring-sealed into the larger tube and the bulb is sealed to the ring seal.
4. The 16 mm. tube is then opened at the extreme end and the side tube is sealed over the opening. The seals are then carefully annealed. When these seals are properly made, the mercury can be raised over the cut-off and the entire volume at the ring seal is completely filled.

Bourdon Gages

Many other gages belong in the class which operate on the principle of balancing an unknown against a known pressure. These gages are used only when experimental studies are made with corrosive gases where mercury cannot be used, or when measurements must be made at temperatures considerably above room temperature. Gages of this type may be made sensitive to 0.1 or possibly 0.01 mm. of mercury. The gage becomes quite fragile if it is made for high sensitivity.

A glass Bourdon gage is shown Fig. 130A. The thinwalled tube which is shaped in a semi-circle is deformed when a pressure gradient exists between the inside and outside of



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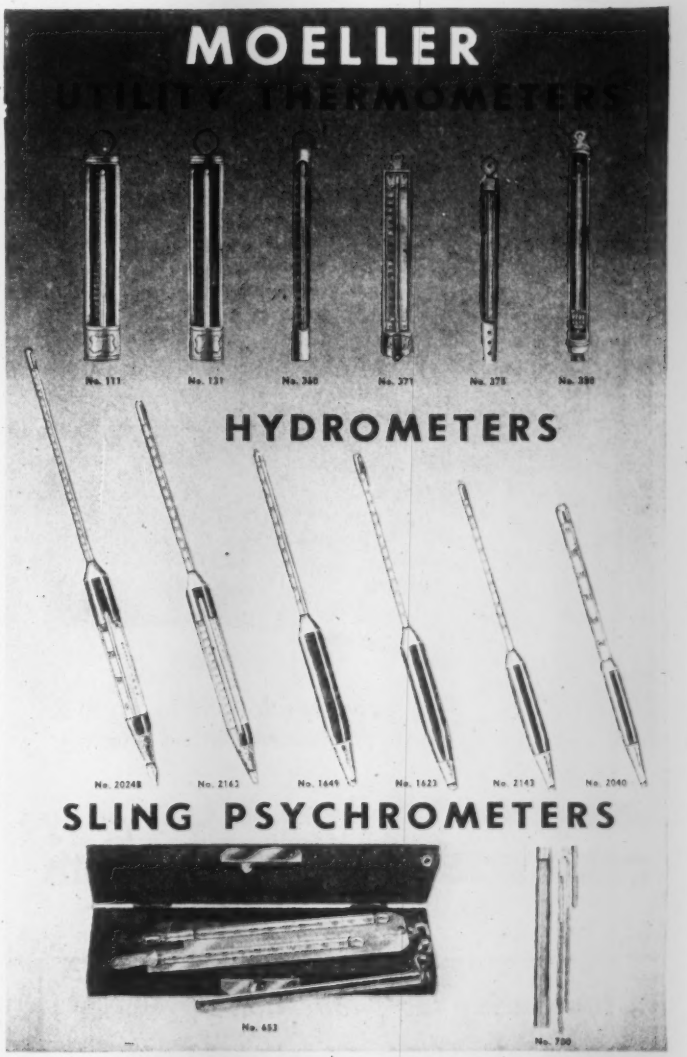

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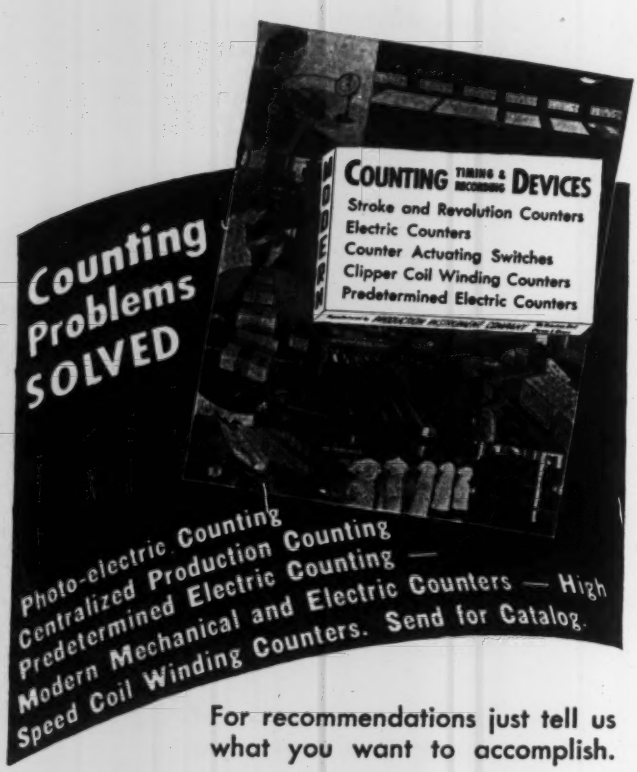

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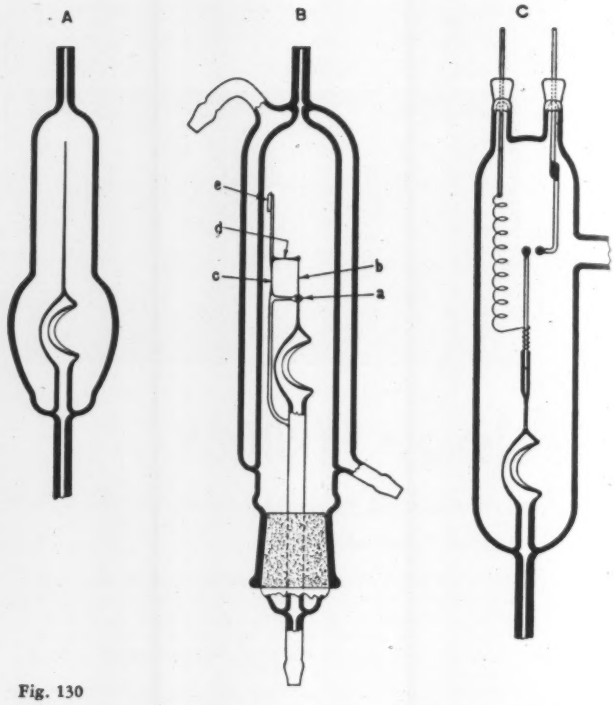

Fig. 130

the tube. The gage is used as a null-point instrument since a known pressure must be used on one side of the tube to bring the unbalanced tube to a zero point.

To be continued

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State of Pennsylvania, County of Allegheny, (ss).

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Richard Rimbach, who, having been duly sworn according to law, deposes and says that he is the Publisher of *Instruments* and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily, weekly, semiweekly or triweekly newspaper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946, embodied in section 537, Postal Laws and Regulations, to wit:

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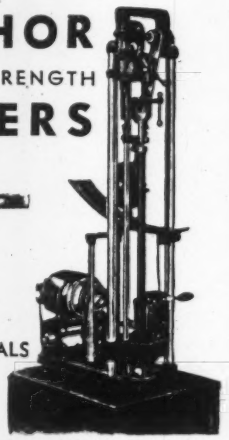

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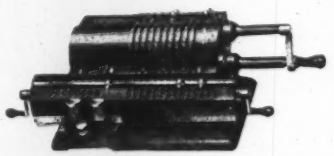

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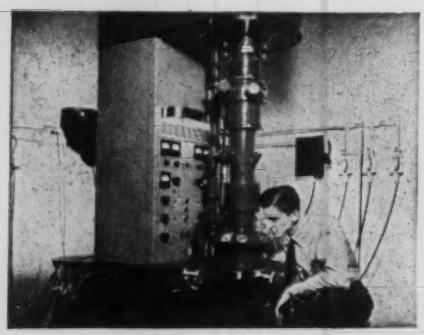

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Hydraulic-power Follow-up System with Pneumatic Tracking

New "Follow Up Unit" is an air-coupled hydraulic unit which will follow the contour of a template cut from light-gage stock or

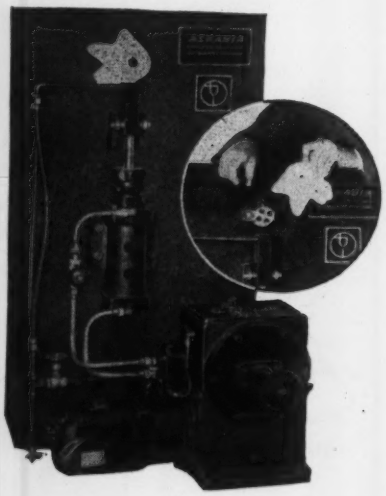

Fig. 1

even stiff paper: there is no wear of template. Circle inset in Fig. 1 shows ease of changing templates, which is important in short production runs. New unit is designed to obviate need of constructing costly cams and to remove travel limitations inherent in mechanical cam mechanisms. It is claimed that there is no limitation in power amplification, which can be a few pounds or several tons of output, for practically no input force. Torque necessary to move template

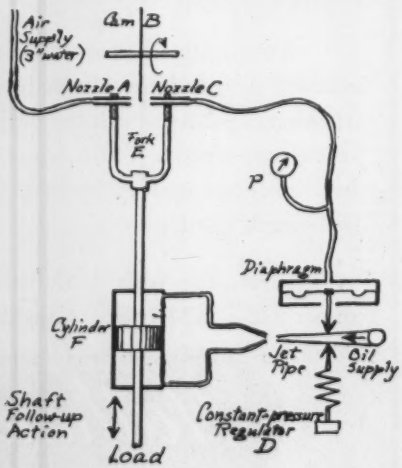

Fig. 2

cam is practically nil. Operation is explained in Fig. 2: part of air from nozzle *A* blows across edge of template *B* to nozzle *C*. Regulator *D* maintains pressure *P* constant and thereby maintains nozzles opposite edge of template *B*, simultaneously positioning load rod. System is stable and has an accuracy of about two thousandths of an inch, with a speed of 20" per minute, in its standard design. In addition to use with templates, unit can be used for "tracking control" of running material such as paper, where mechanical tracking is difficult or impossible.—*Askania Regulator Co., 1603 S. Michigan Ave., Chicago 16, Illinois.*

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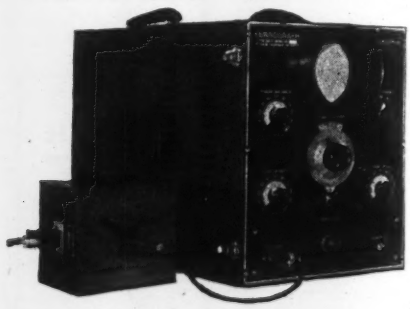
Ferrous-materials Comparator

New "Ferrograph" utilizes correlation between magnetic and metallurgical properties, makes possible determination of com-



position and condition of ferromagnetic materials by magnetic testing, with a cathode-ray tube indicator. Principle is harmonic analysis of induced voltage in secondary of a transformer with test sample as core. By indicating amplitudes and phase angles of fundamental and third harmonic components, "Ferrograph" is said to be suitable for use by unskilled industrial personnel. It uses an energizing field of a frequency below 25 cps., with magnetic field reversals slow enough for an appreciable effect to be obtained from remanent magnetism. "Ferrograph" is housed in 14" × 18" × 24" steel case equipped with two carrying handles, is completely self-contained with its own power pack, operating on 110-volt a-c. supply, weighs 115 lbs.—*Allen B. Du Mont Labs., Inc., 2 Main Ave., Passaic, N. J.*

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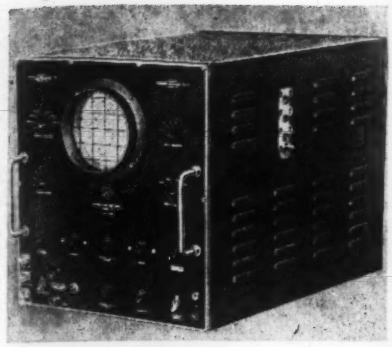
Synchroscope

New synchroscope is specially designed for visual examination of fine structure of periodic wave-forms in television, pulse time modulation, sonic depth-finders, geophysical exploration and loran equipments. It includes a 5" cathode-ray oscilloscope; trigger generator for synchronization; space for addition of a video amplifier and r-f. envelope viewer; adjustable time delay



phasing circuits; and seven input connectors and selector switch for rapid viewing of separate external circuits. Many combinations of trigger and sweep pulses may be produced to feed synchronizing pulses to a variety of external equipments at pulse repetition frequencies up to several thousand per second. Synchronized voltage wave-forms are produced on c-r. tube screen for visual study. Sweep speeds of 0.01; 0.05; 0.2; 1; 2; and 5 in./μsec. with a minimum sweep amplitude of 4" on a 5" c-r. tube are provided. Sweep may be started with external positive or negative signal; delayed up to 90/μsec. from internal trigger; or sweep repetition frequency may be determined by internal or external trigger. Internal trigger output characteristics provide a repetition frequency of 500, 1000, 2000 and 5000 pps., a positive pulse reaching 200 volts minimum in 0.3/μsec., adjustable in time from 75/μsec. before to 25/μsec. after start of sweep. New synchroscope is rated at 200 watts, 105-125 volts, 50-60 cycle a-c. and is supplied with or without an r-f. detector and video amplifier.—*Electronics Div., Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.*

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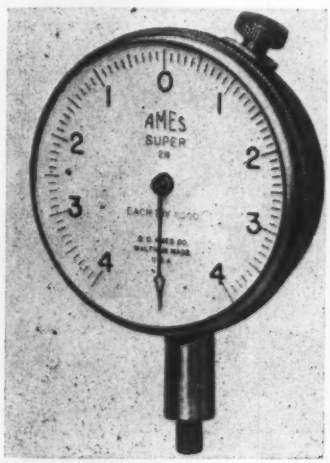
Dial Indicators Sensitive to Ten Microinches

New "Super" series of master checking dial indicators is characterized by low values of internal friction (less than 10



grams) and contact pressure (50 grams) so that indicator can follow variations in dimensions as small as ten microinches. Announcement states that practical readable accuracy is ¼ of a "tenth" division, or 25 microinches. Overall bezel diameters of new models are those of maker's "200" and "300" Series, 2¼" and 2¾", respectively. Graduations are 0.0001". Range is 0.008", with dial either balanced (4-0-4), or continuous (1-0-8). Every bearing is jeweled. Applications of new indicators are as master check; both in toolroom and on production line; as surface analyzers (with

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a diamond contact) to check trueness and finish of ground surfaces, chatter of tools or work, etc. All outside dimensions of new indicators are in accordance with AGDC standards. A variety of backs, to suit desired mounting, is available.—*B. C. Ames Co., Waltham 54, Mass.*

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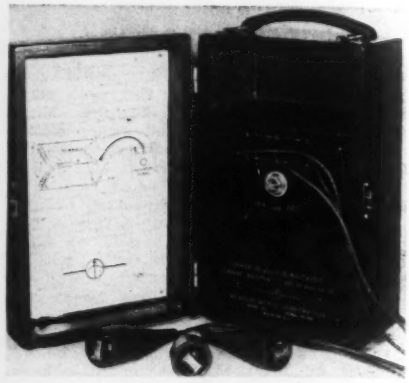
Phase Sequence Indicator

New Phase Sequence Indicator is ruggedly constructed for industrial use, while being of laboratory grade and suitable also for



classroom use in study of vector relations. Unlike conventional types of phase sequence indicators which include a small polyphase motor, this new instrument has no moving parts, no leads to connect to indicator and no separate taps for different voltage circuits. Operating principle is based on Y circuit: one leg pure resistance with gas-discharge tube as voltage indicator; other two legs capacitive and inductive. Instrument is suitable for 50- to 60-cycle operation and can be applied to voltages from 100 to 1000. Walnut carrying case (11″ × 5½″ × 7″) has compartment for 6-foot leads.—*Measurements Corp., 116 Monroe St., Boonton, N. J.*

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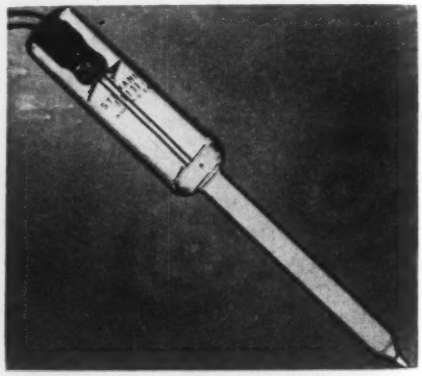
Vacuum-gage Tubes

New Pirani tubes, for continuous direct readings of low gas pressures, are suitable also as leak detectors in evacuating appa-



ratus and for pressure recording and automatic-control equipment. They are designed with tungsten filaments having a high temperature coefficient of resistance permitting direct readings of gas pressures. Matched pairs of Pirani tubes are recommended for greater accuracy: one tube sealed into evacuating system, reference tube opened to surrounding air or filled with a specific gas to a standard pressure (both mounted in close proximity to provide same ambient and installation shielded from radiant heat or air currents). Readings may be obtained with ± 5% accuracy within a pressure range of 1 to 1000 microns. Tubes are supplied in Nonex glass envelopes with

tubulation for direct sealing into apparatus. Over-all length is approx. 8". Tubes are designed to operate at 1.5 volts, 100 ma. Cold resistance of filament is 6.6 ohms. Hot resistance at 100 ma. in evacuated tube ranges from 15.5 to 17.0 ohms.—*Electronics Div., Sylvania Electric Products Co., 500 Fifth Ave., New York 18, N. Y.*

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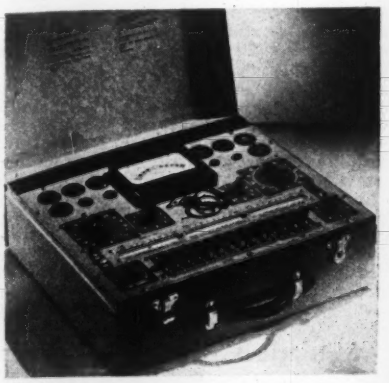
Electron Tube Testers

Two new electron tube testers, "Type 139" (counter) and "Type 140" (portable), are suitable for shop, home, industrial electronic



applications, automobile and mobile radio equipments. Checks of receiving type tubes used in broadcast receivers, FM, television, industrial electronic controls and photoelectric devices may be made under dynamic conditions and without damage to tubes. Design of new testers includes extra sockets and switch contacts for modernization as new types of tubes are developed. Both instruments are supplied for 105-125 volts, 50-60 cycle a-c. operation and are rated at 20 watts.—*Radio Tube Div., Sylvania Electric Products Inc., 500 Fifth Ave., New York 18, N. Y.*

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Aircraft VHF Receiver

New "RV-1-B" crystal-controlled fixed-frequency VHF receiver is specifically designed to meet requirements of airlines.

Using 140 volts plate supply, and with a panel 5¼" high, "RV-1-B" produces an undistorted audio output of 1 watt over a frequency range of 100 to 162 Mc. with a signal-to-noise ratio of better than 2:1 for a 2-microvolt signal modulated 30%. Amplified AVC audio output changes less than 4 db for signal inputs between 10 and 100,000 microvolts.—*Radio Receptor Company, 251 West 19th Street, New York 11, N. Y.*

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Oxygen Indicator

New "Type C Oxygen Indicator" for measuring oxygen content of gaseous mixtures features an electrolytic detector cell is made up of a plastic container with a hollow carbon tube and metallic plate serving as electrodes in approx. 1 oz. of liquid electrolyte. Polarization in cell causes hydrogen to be deposited on carbon pole. When a gas sample containing oxygen is passed through hollow carbon electrode, diffusion through porous carbon causes oxygen to combine with "electrolytic hydrogen," reducing in-

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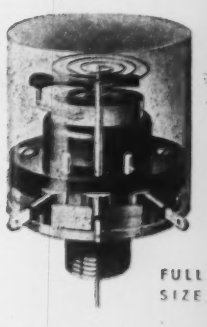

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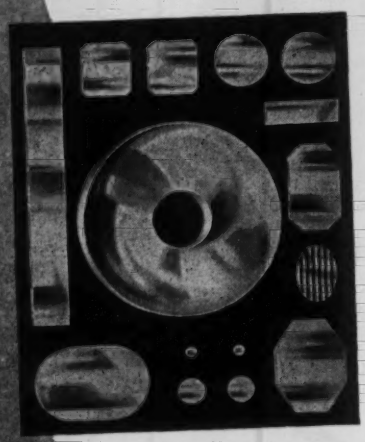

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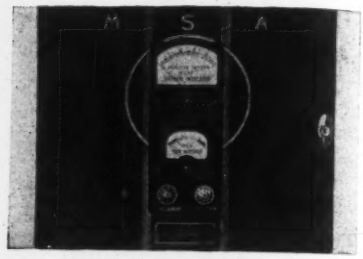
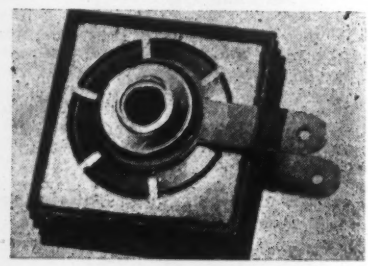


ternal resistance of cell and increasing voltage output. A direct-reading indicator with linear scale indicates percent of oxygen in sample. New Oxygen Indicator is available in four full-scale ranges: 0 to 0.5%, 0 to 5%, 0 to 10%, and 0 to 25%. An adjustable high-point contact can be used for actuating warning signals or control circuits whenever oxygen concentration exceeds a predetermined limit.. New Indicator requires a sample flow of only 25 to 75 cc. per minute. Calibration and zero-adjusting circuits are independent of each other. Provision is also made for attachment of recording instrument.—*Mine Safety Appliances Co., Braddock, Thomas, and Meade Sts., Pittsburgh 8, Penna.*

Please mention number 1109 when filling out card

Miniature Selenium Rectifier to Replace Rectifier Tubes

New "5M1" miniature five-plate selenium rectifier is designed to replace such rectifier tubes as 25Z5, 35Z5, 117Z6, 0Y4 and others.

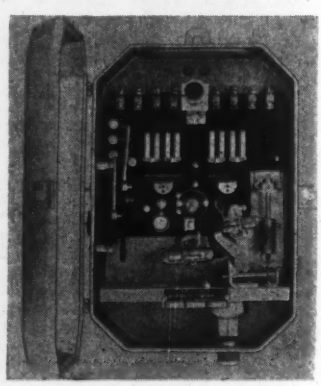


Measuring 1" × 1" and occupying less than 1 in.^{3}, new unit is said to feature high current capacity and low loss, thereby assuring ample safety factor and long life. It will not break and its simple installation saves assembly time. Cooler operation of equipment is assured. No warm-up time is required. "5M1" is to be used with 25-ohm series resistor and maximum capacitance of 40 mfd. Maximum continuous current is 100 ma. at an ambient temperature of 85° C. D-c. output voltage and maximum a-c. input voltage 130 volts. — *Seletron Div., Radio Receptor Co., 251 West 19th Street, New York 11, N. Y.*

Please mention number 1110 when filling out card

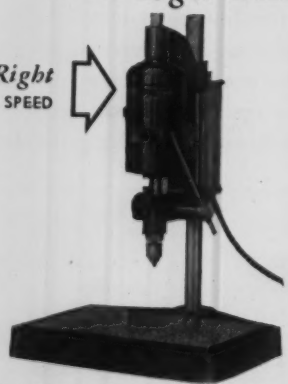
Pump Safety Controllers

New "Protectrol" prevents deep well or centrifugal pumps from running more than a predetermined interval without discharg-



DO *Your Drilling* AT THE *Right* SPEED

THE *Right* DRILL SPEED



The *right* drill speed is instantly available with Electro-Mechano finger-tip speed control. The *right* speed is maintained without further adjustment regardless of the number of pieces or the type of material drilled.

8" Bench Drill Press

Drill heads available for multi-drill production set-ups — will operate in any position. 1000 to 10,000 or 2500 to 15,000 RPM speed range

For holes .004" to 5/32"; .0001" chuck run-out

Bulletin 104

The ELECTRO-MECHANO Co.

261 E. Erie — Milwaukee 2, Wis.

STATHAM PRESSURE TRANSMITTER

Model P-6

The simple means for electrical remote indicating or recording of gas or liquid pressure. Natural Frequency: 1000 cps. Input: DC at 50 milliamperes Full Scale. Output: as high as 150 microamperes. No amplification needed. Operates panel type meters or high speed recorders directly. Types for gage, differential, or absolute pressure measurements. Full scale ranges from 0 - 1 psi to 0 - 50 psi. Other models to 10,000 psi.

Simple - Accurate - Stable - Compact

STATHAM LABORATORIES INSTRUMENT MAKERS

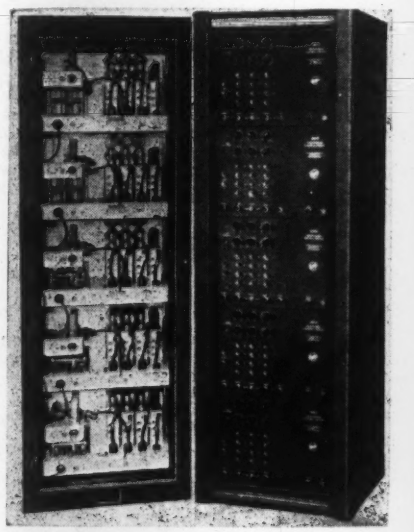
8222 BEVERLY BOULEVARD
LOS ANGELES 36, CALIF.

mg water; is not a primary control device for automatically starting pump but is used in conjunction with either manual or automatic primary control: it is inoperative unless primary control has called for pump operation by pulling in the starter. It is available in two types. "Class I Protectrol": (1) stops pump if water is not discharged within a definite interval after starter is energized; (2) locks starter out irrespective of primary control until "Protectrol" is manually reset; (3) energizes audible alarm circuit the moment "Protectrol" stops pump; (4) simultaneously lights built in warning light which continues to burn until "Protectrol" is reset; (5) is equipped with automatic reset type Alarm Silencer which permits silencing while trouble is corrected; (6) pushing reset button restores all circuits to operate again as occasion arises. "Class II Protectrol": (1) stops pump if water is not discharged within a definite interval after starter is energized; (2) locks starter out irrespective of primary control until manually reset. (Note that "Class II Protectrol" does not operate either alarm bell or light.)—*Automatic Control Co., 1005 University Ave., St. Paul 4, Minn.*

Please mention number 1111 when filling out card

Electronic Counters in Multiple

New "Potter Electronic Counter in Multiple" consists of five "Model No. 69-3 Dual Predetermined Electronic Counters," in each

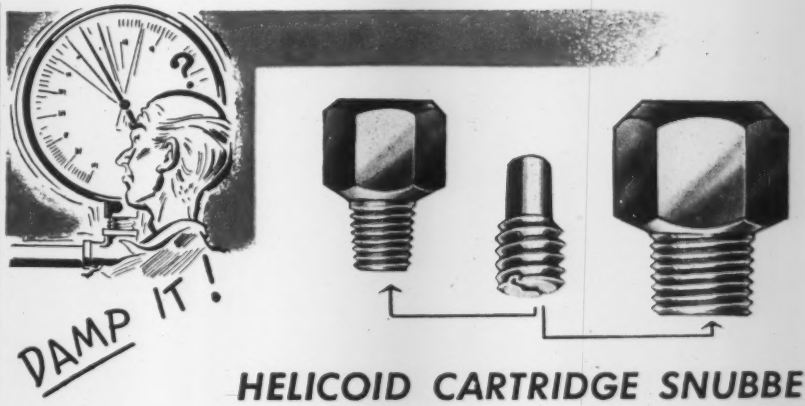


of which three 4-tube decades are employed. Counting rates as high as 12,000 per minute may be attained. For actuating input to counter a simple contactor or a photoelectric pick-up may be used. Output is provided with a single-contact double-throw high-speed relay for initiating control function (most often performed by a fast-acting solenoid). Modifications of this equipment are available to satisfy specific requirements.—*Potter Instrument Co. 136-56 Roosevelt Ave., Flushing, N. Y.*

Please mention number 1112 when filling out card

Multiple Switch for Switchboard Instrument Testing

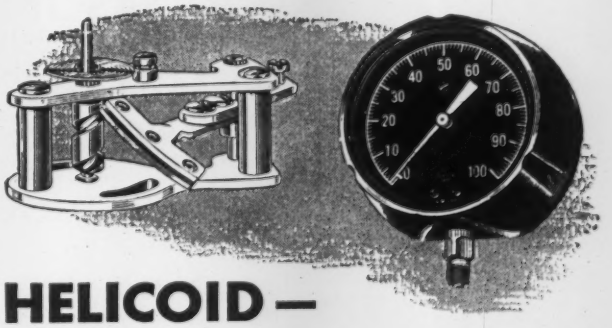
New "Flexitest" test switch for rapid testing of switchboard instruments, meters and relays from front of board is available in models with up to ten elements and rated at 250 volts, 30 amperes. Combinations of current and potential switches are included as required for the various types of instruments to be tested. Safety and accuracy are enhanced by construction whereby a plug properly connected to the test instruments can be used to check, from front of board in rapid succession, all meters or instruments of a particular type. "Flexitest" switch is enclosed in a black Moldarta case with cover of similar material



HELICOID CARTRIDGE SNUBBER

...THE SIMPLEST OF ALL
PRESSURE GAGE SNUBBERS

... for use where pulsations of gage pointer make accurate reading difficult or impossible. Damping action assured by porous cartridge of compressed, powdered bronze, threaded into gage socket or into snubber body. No adjustments ever needed. Specific porosity of cartridge makes it effective for required service – air, gas, water, steam or oil. Available for all pressures up to 10,000 pounds. May be supplied with Helicoid Gages or bought separately for use with other gages.



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A DIFFERENT KIND OF PRESSURE GAGE

The unique design of the Helicoid movement – with cam and helical roller instead of gears – obsoletes conventional type pressure gages. A Helicoid Gage will maintain its guaranteed accuracy longer – a fact proved in thousands of installations. For complete information, write for our Catalog DH-818.

ACCO

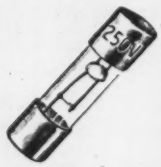
HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

TRADE MARK

Littelfuse precision-built fuses are so inexpensive that every manufacturer can effectively protect his product and reputation at relatively small cost. Complete range of types and sizes for instruments, small motors, radio and electronic circuits, automobile, aircraft and marine instruments, and all types of electrical equipment. For complete information on these and other Littelfuse quality products, send for Catalog No. 9 . . . just off the press.

FUSE EXTRACTOR POST for 8AG fuses. Finger operated. Also available with screw-driver slot knob. A quicker, safer, simpler method for mounting and changing fuses.

METER-BACK MOUNTING for 8AG fuses. Mounts direct on one meter binding post and wire connects to screw terminal of Mounting. Overall length only 1½".



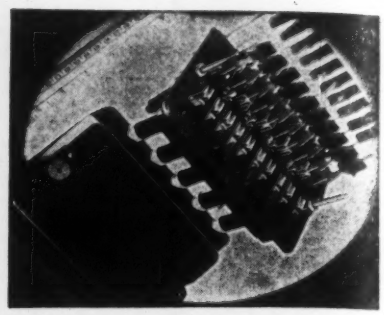
8AG FUSE. "Quicker than a short circuit." Precision designed and built. Note bridge-type construction which protects the delicate filaments in fuses of very low fractional amperage.

LITTELFUSE Incorporated

FIRST IN CIRCUIT PROTECTION

4765 N. RAVENSWOOD AVE. CHICAGO 40, U.S.A.

NITE-T-LITE • SWITCH-LITE • IGNITION-FRITZ • NEON INDICATORS • SWITCHES • CIRCUIT BREAKERS • FUSES, MOUNTINGS AND ACCESSORIES



that blends with instrument and relay cases and with panels. Its width is such that it can be mounted on the same centerlines as standard instruments and relays. Individual switches are of knife-blade type and separated by barriers. Switch handles are recessed for inserting identification cards and each is drilled for insertion of an interlocking bar to tie together any three adjacent handles. Right-hand switch, when used for a trip circuit, is provided with a red handle for easy identification. Means are provided for attachment of spring clips when individual test leads are used instead of a test plug.—*Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Penna.*

Please mention number 1113 when filling out card

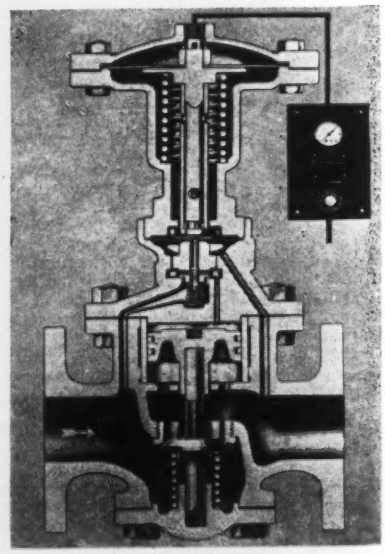
Selenium Rectifier Elements

New 5" × 5¾" selenium rectifier plates built on aluminum were developed specifically for high current capacity, are especially applicable for electroplating and battery charging, but not limited to this use. New plates are said to combine long life and minimum weight with maximum heat dissipating value.—*Selectron Div. of Radio Receptor Co., Inc., 251 W. 19th St., New York 11, N. Y.*

Please mention number 1114 when filling out card

Remotely-adjusted Regulating Valve

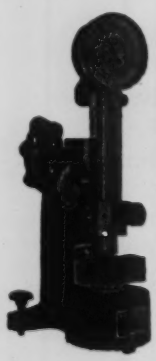
New "Class LT-3" single-seated internal-pilot piston-operated reducing valve designed to be remotely adjusted from a con-



veniently-located "Type ARP" air-loading panel, is especially adaptable to process piping arrangements that require hazardous or inconvenient readjustments of inaccessibly-located valves to meet changing conditions. Air-loading panel includes a small ⅛" combination pressure reducing and relief valve (no continuous leak-off) mounted on a panel containing an adjusting knob and a large easily-read air pressure

HARDNESS TESTING...

done WITH NO METAL HAZARDS. The SCLEROSCOPE has done it for the past 39 years.



In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

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The Shore Instrument & Mfg. Co., Inc.

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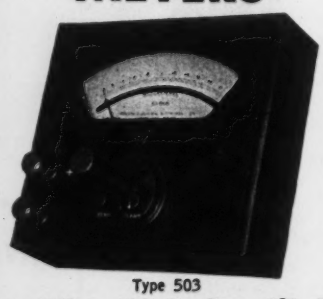
RAWSON SEMI-SUSPENDED METERS



Type 503

for Ultra-High Sensitivity

0.5 Microampere Full-Scale (7000 ohms)
0.24 Millivolt Full-Scale (10 ohms)
High Resistance Voltmeters (Megohm per Volt). Many other ranges.
Accurate Portable Meters need no leveling. Will often replace light-beam galvanometers or vacuum tube voltmeters.

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WE ALSO SUPPLY
REGULAR DC METERS
THERMOCOUPLE AC METERS
MULTIMETERS
FLUXMETERS
ELECTROSTATIC VOLTMETERS
Special apparatus built to order

RAWSON ELECTRICAL INSTRUMENT COMPANY
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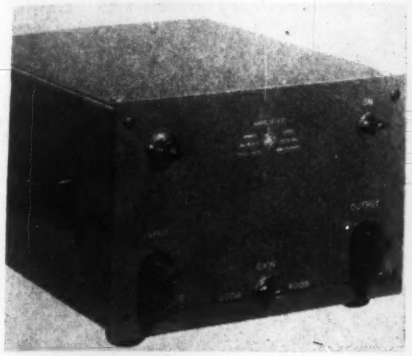
Representatives
CHICAGO LOS ANGELES NEW YORK CITY

gage. In operation, reducing valve is adjusted to desired pressure setting by air pressure supplied by air-loading panel. Constant loading force on upper diaphragm of reducing valve opens controlling valve and is balanced by a constant reduced pressure proportional to loading force, thereby maintaining a constant reduced pressure. Furnished in high-pressure bronze or cast steel body with flanged or screwed ends, new valves have completely-interchangeable replacement parts, stellited seat rings, and hardened stainless-steel 800-Brinell main valves as standard equipment.—*Leslie Co., 885 Delafield Ave., Lyndhurst, N. J.*

Please mention number 1115 when filling out card

Amplifier

New "450A" wide-band amplifier for general purpose or laboratory use is said to provide unusual stability at 40-db or 20-db

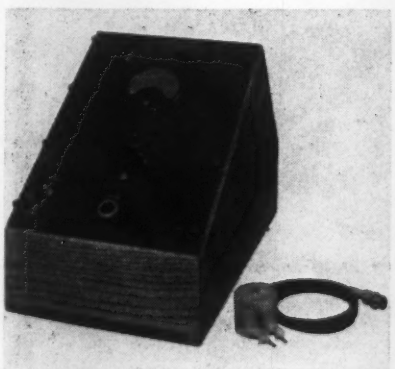


gain. Low phase shift is assured by a straightforward resistance-coupled amplifier design, together with inverse feedback. Frequency response is flat within ½ db between 10 and 1,000,000 cycles. Input impedance is 1 megohm shunted by 15 mmfd. Internal impedance is less than 150 ohms over entire range. Varying tube voltages or aging tubes are said to have no appreciable effect on gain or other characteristics. New amplifier operates from a 115-volt 60-cycle power supply; and when used in conjunction with maker's "400A" Vacuum-tube Voltmeter, increases voltmeter's sensitivity by 100 times (300 microvolts full-scale) at 40 db. At 20-db gain, sensitivity is multiplied 10 times (3 millivolts full-scale). Both instruments have identical base sizes to permit easy stacking and short leads.—*Hewlett-Packard Co., Palo Alto, Calif.*

Please mention number 1116 when filling out card

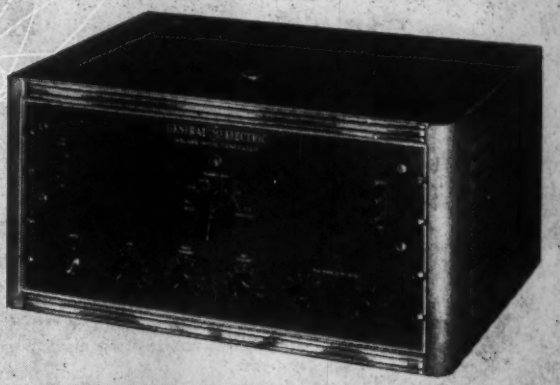
Vacuum-tube Voltmeter

"Series 200A" new vacuum-tube voltmeter has full-scale sensitivity of 0.5 volt for use at radio and audio fre-



quencies. Stray capacitances and detuning effects are minimized by bringing voltmeter input connections as close to circuit to be measured as possible: by lead wires or by a contact-clamping fixture for production work. Unit has an external probe to which

To test over-all performance



SQUARE-WAVE GENERATOR

● This unit, generating its own frequency or synchronized from an external source, will be found invaluable in many fields. FM, AM and Television Broadcasting—Telephone and Telegraph Communications—Manufacture of Transmitting and Receiving Equipment and Parts.

● Many additional functions will recommend it for use in school and college research projects and in scientific laboratories.

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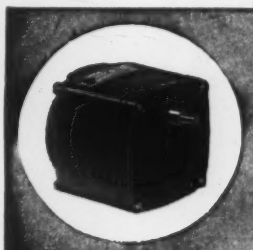
For additional information write: *Electronics Department, General Electric Company,* Syracuse 1, New York.

Electronic Measuring Instruments

GENERAL ELECTRIC

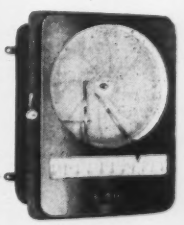
164-81



PRECISION MOTORS for important instrument applications

TYPE K MOTOR IN BRISTOL PYROMETER

The Bristol Pyromaster Pyrometer shown is one of a series of similar instruments in which the Bodine motor operates the potentiometer, or measuring, device.



The operating motor in a precision instrument is the heart of that instrument. Unless it performs properly, the rest of the mechanism is useless. That's why the choice of a motor is a big factor in instrument design.

Bodine motors are found in many important instrument applications, because long use has demonstrated their reliability. Not only are they widely used in production instruments such as the one shown at the left, but also in many laboratory devices.

If you have a motor application problem, why not let Bodine engineers help you. Bodine Electric Co., 2244 W. Ohio St., Chicago 12, Ill.

BODINE FRACTIONAL HORSEPOWER MOTORS

INKLESS TEMPERATURE RECORDER

remote recording from resistance temperature detectors

Consisting of two compact units (an inkless strip-chart recorder and an external power unit), the new G-E Type CF-2 temperature recorder can be used with resistance temperature detectors (RTD's) already installed in generators, transformers, and other large electric apparatus, or with separate detector units to record temperature in ovens, heat-treating tanks, refrigerating machines, air ducts, and liquid-handling systems.

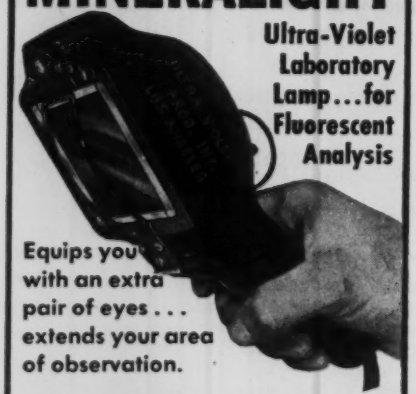
ELECTRICALLY OPERATED—SCALE RANGE 20-140 DEGREES C

On a four-inch strip chart, this equipment produces a clear record of the temperature variations that effect resistance changes in standard, ten-ohm RTD's heretofore used mainly with indicating instruments. The 115-volt Telechron motor can be adjusted to provide record lengths of from eight days to two years on a single 65-foot chart. By using a suitable transfer switch, a single equipment may be used with several detector units for multiple recordings.

Lightweight and portable, the Type CF-2 temperature recorder is probably the lowest-priced, remote-recording instrument on the market. And to suit diverse requirements, a variety of RTD's are available as accessories. Complete details are listed in Bulletin GEA-4572. Call the nearest G-E office for your copy or write to *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

MINERALIGHT



Ultra-Violet Laboratory Lamp...for Fluorescent Analysis

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Tachometers

MAINTAIN RPM AND PRODUCTION RATES IN YOUR PLANT

STATIONARY MODELS

Dials, 3", 4", 5½", 8", 10", and 20" in diameter.

Dials to read RPM, FPM, YPM, sheets per minute, gallons per minute, books per minute, or any other special operation.

WRITE FOR BULLETINS Nos. 795, 796, 797, 798

PORTABLE MODELS

Centrifugal or Chronometric type with 1, 3, or 5 ranges in one instrument, all speeds from 0-100,000 RPM.

WRITE FOR BULLETINS Nos. 780, 760, 790, 750, 755, 735

NEW CONDENSED CATALOG No. 1046 SHOWS ALL TACHOMETERS

STOP WATCHES IMPORTED SWISS

Large assortment of Gallet and Minerva watches of highest quality and accuracy 1/5 second, 1/10 second, 1/100 second timers. Also decimals (minute divided into 100 parts).

WRITE FOR BULLETIN No. 575

HERMAN H. STICHT CO., INC.

Tachometer Headquarters

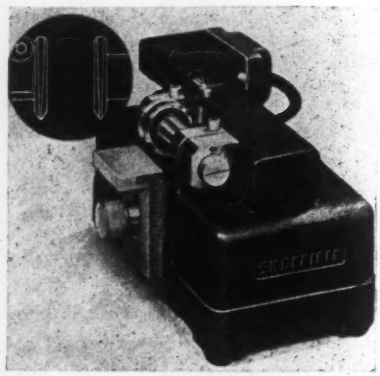
27 PARK PLACE NEW YORK 7, N. Y.

connections can be soldered and binding posts that can receive wires or banana plugs. Input tube is a plate circuit rectifier type in which input voltage is rectified under full-wave square-law operating conditions and indicates RMS values. Rear storage compartment contains a source of calibration voltage equal to 5 RMS volts ±2%. Chassis is of aluminum alloy, caustic dipped to prevent corrosion in salt atmosphere. All resistors used for calibration are precision wire-wound with negligible temperature drift. All capacitors are oil, paper, or mica. Cabinets are copper-lined to prevent extraneous radiofrequency fields from affecting accuracy.—*Televiso Products Co., 7466 Irving Park Road, Chicago 34, Illinois.*

Please mention number 1117 when filling out card

Thread-lead Checker

New "Production Leadcheck" has adjustable truncated cylindrical gaging anvils (see inset in illustration) which make possible

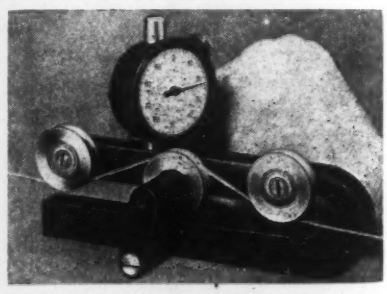


production checking of thread lead within a range of 4½ to 60 threads per inch to an accuracy of 0.0001". It may be had with either a "tenth" dial indicator or an "Electrigage" for more accurate gaging. Adjustable truncated cylindrical gaging anvil can be moved and locked in place at any point within a range of 0.200" to 2.000". Both gaging anvils are adjustable for desired pitch by rotating on their mounting shafts. Inner face of each anvil is held parallel to center line of disk, permitting set-up with gage blocks inserted between inner faces.—*The Sheffield Corp., Dayton 1, Ohio.*

Please mention number 1118 when filling out card

Tensometer for Textiles

New tensometer for thread, yarn or cord has a range up to 100 lbs., can be clipped on a moving, continuous cord, indicates tension



directly in pounds. Handle and frame are aluminum alloy finished with a black anodic coating, grooved wheels are stainless steel.—*Walter Kidde & Co., Inc., Belleville, N. J.*

Please mention number 1119 when filling out card

Aircraft Relay

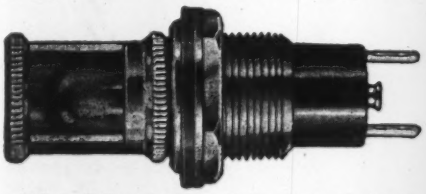
New "Type 7064-534" light-weight d-c. solenoid type relay is designed for feeder type planes and small personal aircraft, is capable of operating at altitudes up to 50,000

feet and at temperatures between 54°C. and 71°C. It is protected against humidity, sand, dust and salt spray and will meet operating conditions up to 10*G* vibration and acceleration. It is supplied with intermittent duty coils for motor starting applications. ("Type 7064-534 C" has duty coils for battery switching, motor control, aircraft and marine radio switching and lighting.) Contacts of special silver alloy are ⅜" diameter, and rated at 100 amperes at 12 volts dc. or 75 amperes at 24 volts dc. Contact arrangement is SPST, double break, normally open. Dependent upon voltage and operating requirements, coils have a resistance of 9.5 ohms to 110 ohms. On intermittent duty, coils consume approximately 15.12 watts, and 5.23 watts for continuous duty. Each relay weighs approx. 8½ ounces.—*Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif.*

Please mention number 1120 when filling out card

Light-shield Pilot Light Assemblies

New series of pilot light assemblies have light-shields. A turn of knurled head directs the light on to any spot, at any desired angle. Head is a friction fit to body, per-



mitting full rotation. It is secured by a snap lock, will not loosen under vibration but is easily removed. Units with different sizes of openings in shields are provided as follows: "Model 21408" has opening ½" wide × ½" long; provides maximum illumination. "Model 89408" 3/16" × 9/16". "Model 90408" ½" × 3/16". "Model 22408" ½" × 3/32". Illustration shows "Model 89408" in actual size. A basic new feature is a built-in resistor for use in conjunction with NE-51 Neon Lamps on 110- and 200-volt circuits. Resistor value is chosen to suit voltage. Use of NE-51 on these voltages assures long life, low current (under 1 ma.), high resistance to mechanical damage, tolerance for wide voltage variation.—*Dial Light Co. of America, Inc., 900 Broadway, New York 3, N. Y.*

Please mention number 1121 when filling out card

Remote-indicating Tachometers

New electric tachometers for permanent installation are particularly designed for use where generator must be mounted permanently on a machine, and indicator mounted on a remote panel. Generator consists of a small, permanent Alnico magnet rotor mounted on precision sealed ball bearings and capable of continuous operation at any speed within indicator's range. Indicating instrument is a rectifier type, including a sturdy d'Arsonval movement capable of withstanding without damage a momentary overload up to four times maxi-

Laboratory Standards

U.H.F. STANDARD SIGNAL GENERATOR *MODEL 84*

SPECIFICATIONS

CARRIER FREQUENCY: 300 to 1000 megacycles.

OUTPUT VOLTAGE: 0.1 to 100,000 microvolts.

OUTPUT IMPEDANCE: 50 ohms.

MODULATION: SINEWAVE: 0—30%, 400, 1000 or 2500 cycles. PULSE: Repetition—60 to 100,000 cycles. Width—1 to 50 microseconds. Delay—0 to 50 microseconds. Sync. input—amplifier and control. Sync. output—either polarity.

DIMENSIONS: Width 26", Height 12", Depth 10".

WEIGHT: 125 pounds including external line voltage regulator.

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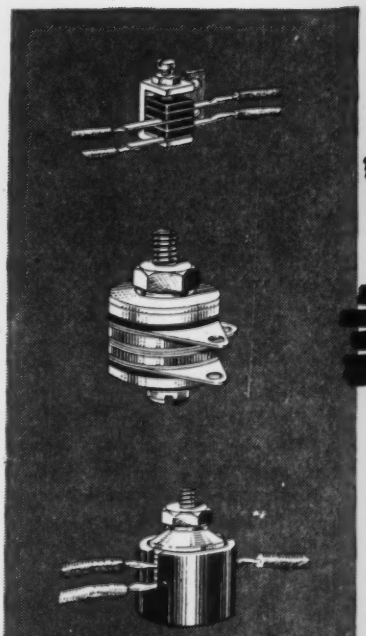

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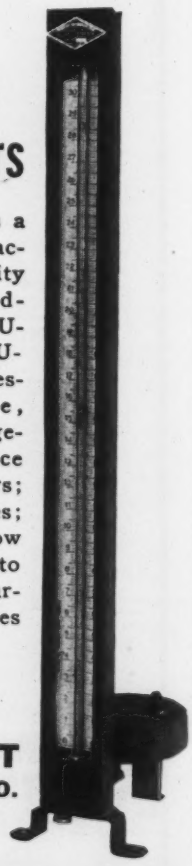
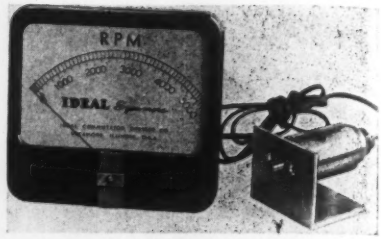




mum speed indication. For installation up to 200 feet, unit may be connected with two-conductor No. 18 insulated wire. For longer distances, maker should be consulted for proper size of conductor. Instruments are available in two sizes: 3", and 7". Both are available in three ranges: 0-1250 rpm; 0-2500 rpm; and 0-5000 rpm.—*Ideal Industries, Inc., 1415 Park Ave., Sycamore, Illinois.*

Please mention number 1122 when filling out card

Automatic Timer

New "Type TA Synchronous Utility Process Timer" is powered with an instantaneous-starting synchronous motor that actuates a pair of heavy silver contacts rated

at 1000 watts or 1-hp. load. A single 3-way outlet mounted on side of case permits connection to load for "on during cycle" or "off during cycle and come on at end of cycle." Silver contacts are snap-acting. Timer operates equally well in any position. Knob is 1½" diameter and ⅞" high for easy operation even with heavy gloves. Minimum time interval that can be set is approx. 1% of full range. Standard time cycles are from 0-15 minutes; 0-30 minutes; 0-1 hour and 0-12 hours. Other time cycles are available on order. Size of unit, 5½" × 3¼" × 3½".—*Potter & Brumfield Sales Co., Dep't. 254, 549 W. Washington Blvd., Chicago 6, Illinois.*

Please mention number 1123 when filling out card

Timing Indicator

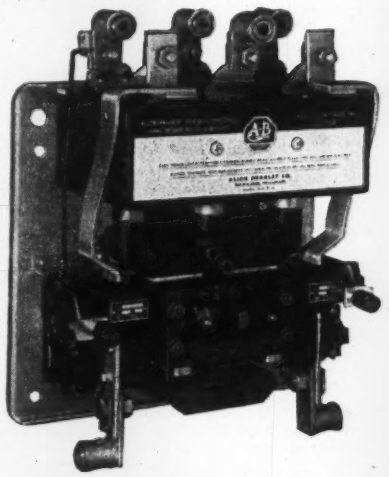
New "Type A Signal Indicator" contains both a buzzer and bright bullseye light; can be mounted in any position; is fitted with a male three-way plug which will connect

directly into socket on "TA Timer," thus giving a unit assembly for timer and indicator, or it may be remotely located at any distance by use of a 3-wire cord. Both buzzer and light can be disconnected if desired. *—Potter & Brumfield Sales Co., Dep't. 254, 549 West Washington Blvd., Chicago 6, Illinois.*

Please mention number 1124 when filling out card

300-amp. Solenoid Starter

New "Size 5, Bulletin 709" solenoid starter has a maximum hp. rating of 100 hp., 220 volts and 200 hp., 440-550-600 volts, replace older "Bulletin 710, Size 5," clap-

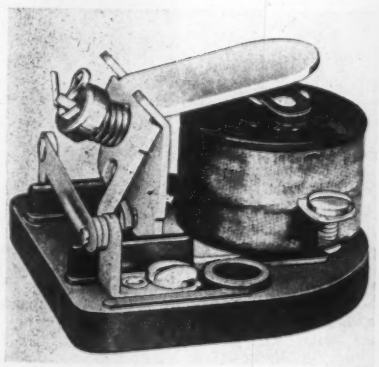


per starter. Contact cleaning, filing, or dressing as avoided by use of double-break cadmium silver contacts totally encased in an arc hood, each pole of switch having its individual arc chamber. Hence, when necessary, new starters can be closely grouped without danger of flash-over between switches. Enclosed starter is available in NEMA Type 1 sheet metal enclosure for general-purpose applications, as well as NEMA Type 4, water-tight and weather-proof; NEMA Type 5, for nonhazardous dust.—*Allen-Bradley Co., 1311 S. First St., Milwaukee, Wis.*

Please mention number 1125 when filling out card

Motor-starting Relay

New "MS2A" positive-action motor starting relay is said to eliminate many difficulties normally encountered with centrifugal throw-out mechanisms. It is voltage-



actuated and operates on back e.m.f. of starting winding. When motor has attained speed, relay immediately disconnects starting coil from line. No overload, with its attendant heavy current flow, can prevent it from positive operation once proper motor speed has been reached. Back e.m.f., induced in starting coil by armature rotation, assures a permanent disconnect as long as motor maintains its rated speed. Because no centrifugal switch is required, "MS2A" is applicable to inaccessible motors such as those which are "sealed in" on refrigerator

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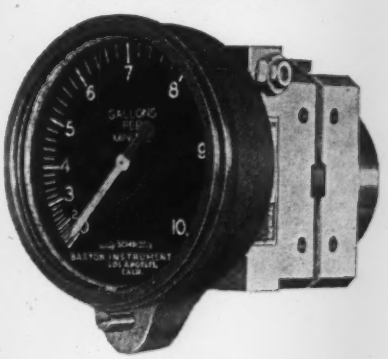

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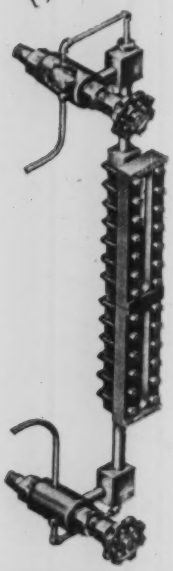

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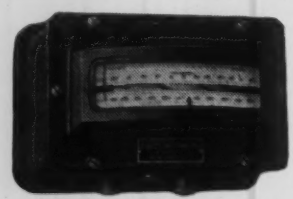

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Switchboard Indicator

Unskilled help may handle this direct-deflection instrument, which needs no manual adjustment. Designed for numerous ranges of temperature, both F. and C.

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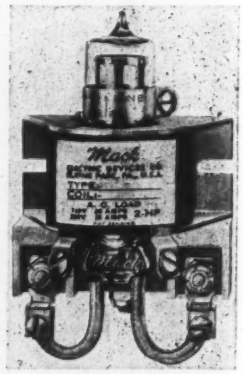
systems; also motors subjected to heavy accumulations of dust, dirt and greases. "MS2A" may be mounted on the motor housing or located at any distance.—*Potter & Brumfield Sales Co., Dep't. 254, 549 West Washington Blvd., Chicago 6, Ill.*

Please mention number 1126 when filling out card

Magnetic-plunger-operated Mercury Relay

New "Mercu-Trol" handles loads up to 2 hp., a-c. loads up to 35 amps. (110-v.) and 25 amps. (220-v.). Operating principle is change of mercury level outside a central

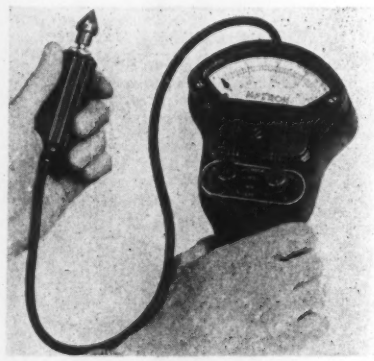


ceramic cup which is always filled with mercury: thus providing an annular mercury-to-mercury make or break, in inert gas, without exposed arc. There is only one moving part. Circuit connections are heavy tungsten bottom leads always submerged in the two mercury reservoirs. Dimensions 2⅝" wide, 2¼" deep, 4½" high.—*Mack Electric Devices Co., 502 Township Line, Elkins Park, Penna.*

Please mention number 1127 when filling out card

Low-speed Tachometer

New "Type 25B" low-speed hand tachometer has 3 ranges of 10 to 200 rpm., 20 to 400 rpm., and 50 to 1,000 rpm., is similar in appearance to standard "Type 25A" which



has ranges of 10 times the above values. Operating principle was described in *Instruments*, Dec. 1945, page 922; May 1946, page 276. Accuracy is 1% of full scale. Instrument is supplied complete in a carrying case with all necessary contact tips and disks for measuring linear speeds. Low- and high-speed adapters are available for extending range down to 1 rpm. and up to 10,000 rpm.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 1128 when filling out card

Chronometric Tachometer

New "Milwaukee Tachometer" utilizes chronometric principle, measures shaft speeds from 1 to 10,000 R.P.M. or belt speeds from 1 to 3,000 F.P.M. in 3-second intervals without gear ratio changes. (High-speed ranges obtainable on special request.) Ac-

curacy is ½ of 1% of measured speed. Instrument weighs 9 oz., has a polished aluminum case, is designed to fit hand comfortably. Convenient operating buttons are provided for starting and resetting. Indicator hands remain at measured speed position until reset button is pressed. Tachometer is non-magnetic up to 2000 lines. Each instrument is individually calibrated, is supplied in case with necessary accessories, including concave, convex and wheel tips, and spare parts.—*Milwaukee Lock and Mfg. Co., 732 W. Virginia St., Milwaukee 4, Wisconsin.*

Please mention number 1129 when filling out card

Variable-voltage Rectifiers

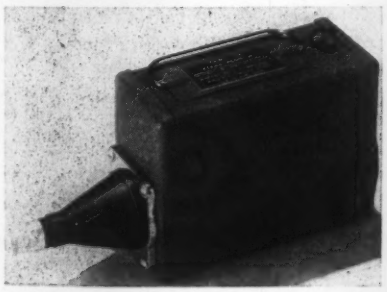
New line of rectifiers provide variable d-c. voltage by rotating large knob located on front panel, instantaneous d-c. power without warm up is obtained by plugging into

110-v. a-c. source. Construction features include convection cooled, conservatively rated, full-wave bridge selenium rectifier; continuously-variable voltage control from zero to maximum: d-c. ammeter to indicate output current (size 3½"); voltmeter to read output d-c voltage (size 3½"); panel-mounted fuse; on and off switch; pilot lamp. Specifications of leading models: "No. 101," input 115-v. 60 cycles; output 12-v. dc., capacity 25 amps; overall size 10" × 14" × 11¾". "No. 102," input 115-v. 60 cycles; output 12-v. dc., capacity 50 amps; overall size 10" × 14" × 11¾". "No. 103," input 115-v. 60 cycles; output 8-v. dc., capacity 150 amps; overall size 28" × 16" × 13½". All models are continuously variable. —*Electro-Tech Equipment Co., 119 Lafayette St., New York 13, N. Y.*

Please mention number 1130 when filling out card

Coaxial Resistor

New "Model 81 Termaline" is a coaxial resistor, coaxial connector design with low VSWR characteristics, designed to dissipate all r-f. power fed to it. It is rated at 50 watts for continuous duty (higher power levels for short periods). Essentially, it con-



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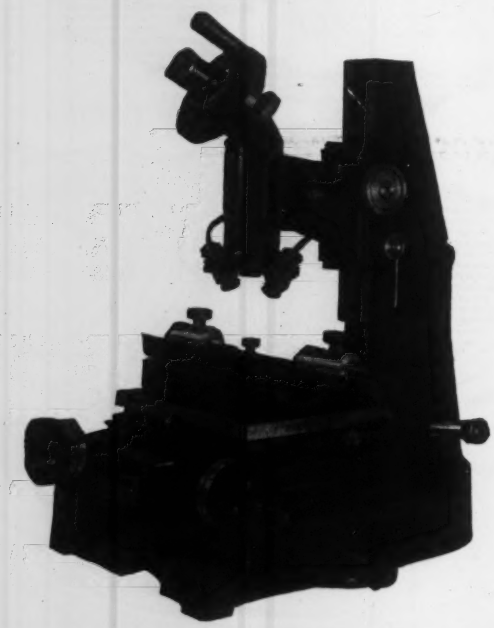

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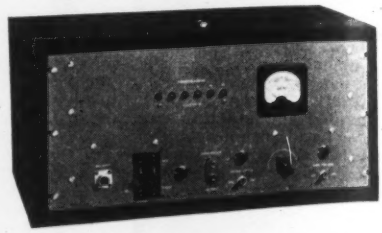
sists of a coaxial resistor immersed in a liquid coolant to increase radiating surface and consequently power dissipation. Case is 6" L × 4½" H × 2⅝" W. Provision for "N" type connector extends ⅜".—*Bird Electronic Corp., 1800 East 38th St., Cleveland 14, Ohio.*

Please mention number 1131 when filling out card

Beta and Gamma Impulse Scaler

New "Model 161 Scaler" for counting beta particles and gamma rays in radioactivity research is said to have many applications in tracer research work in metallurgy, medi-

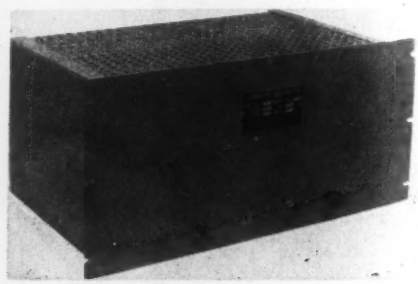


cine, food technology, chemistry, and related fields. It operates on impulses from a Geiger-Müller tube and actuates an external register once for each 64 impulses it receives. Features are self-contained high voltage supply, and no preamplifier required for use with Geiger-Müller tube. Circuit has an input sensitivity of 0.25 volts, and its resolving time of better than 5 microseconds is said to allow for great accuracy even when counting must be rapid. Internal high voltage supply—variable between 600 and 1500 volts—is regulated to better than 0.01% per percent change in line voltage, while scaler is designed to operate on any input line voltage between 95 to 130 volts. "Model 161 Scaler" can be used by inexperienced personnel in either research work or routine counting operations. Chassis can be removed for mounting in a standard 19" relay rack if desired.—*Instrument Development Laboratories, 817 E. 55th St., Chicago 15, Illinois.*

Please mention number 1132 when filling out card

Regulated-voltage D-c. Power Supply Units

New d-c. voltage regulators, Models "E-6" and "E-12," are each available in 5-, 10- and 15-ampere sizes. Input is 100-125 volts,

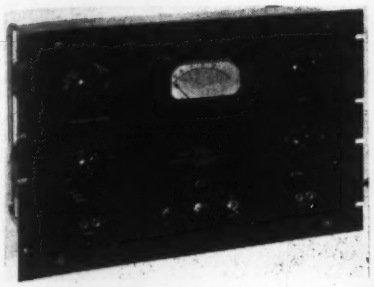


60 cycles; output is 6 or 12 volts, adjustable ±10% and accurate to ±0.5%. Ripple voltage is 1% r.m.s. maximum. Load range is 50% to 100% of rated value for ±0.5% accuracy (accuracy is impaired at no-load or extremely light loads).—*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

Please mention number 1133 when filling out card

Noise Suppressor

New "Type 910-A Dynamic Noise Suppressor" is said to make negligible background noise level, heretofore possible only with direct recordings and the best transcriptions, obtainable with ordinary shellac and vinyl pressings. Method of noise suppression is based upon a new application of well-known principles of physics and acoustics: through use of a newly developed "gate circuit," all musical components which

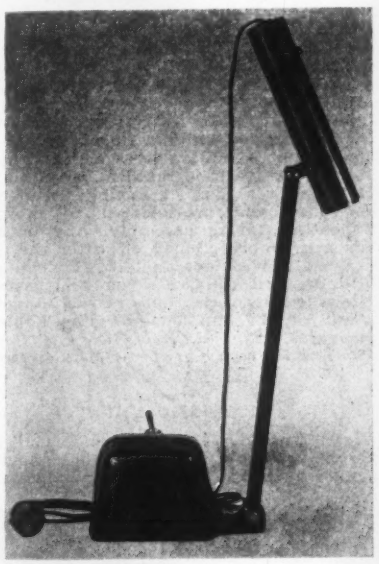


contribute significantly to realism of reproduction are said to be transmitted with substantially no attenuation. At the same time transmission is substantially eliminated for other portions of the audio spectrum which contains large amounts of noise. Action of "gate circuit" is practically instantaneous, so that each note of each phrase is transmitted with an optimum quality-to-noise ratio.—*Technology Instrument Corp., Waltham, Mass.*

Please mention number 1134 when filling out card

Spot-light for Inspecting Holes

New "Inspect-A-Hole" gives brilliant illumination to sides and right down to bottom of small holes, as deep as 3" or 4", making it especially useful for inspection of holes

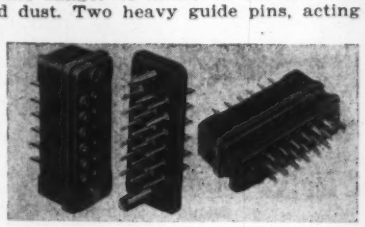


for broken taps and drills, as well as for production jobs that require a concentrated beam of light. Feature of new light is that housing does not obstruct, both eyes being focused simultaneously with the light into the hole. Illustration shows it for bench use, but manufacturer can furnish it equipped with a handle for portable use. — *Wm. Buchele, 1309 Milburn Ave., Toledo 6, Ohio.*

Please mention number 1135 when filling out card

Connector Block

New "Monoblock" multiple-contact connector is particularly adapted to limited space applications, can also be supplied with a self-contained locking device which obviates need of any external clamping arrangement. One-piece molded Melamine inserts reduce danger of flashover due to moisture and dust. Two heavy guide pins, acting as



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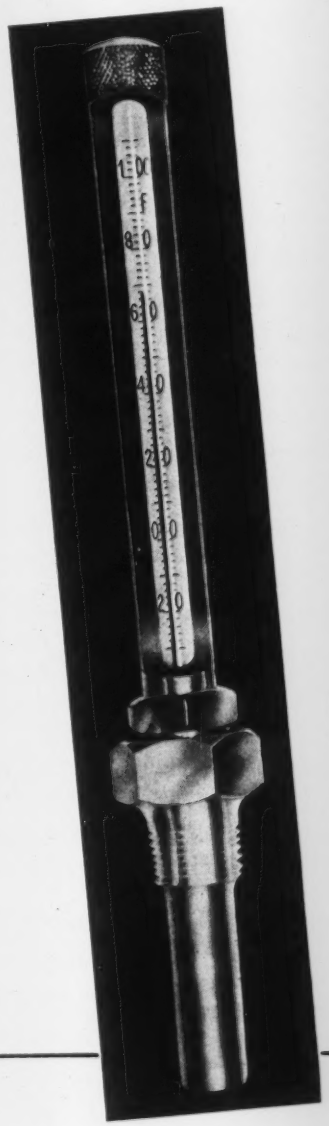

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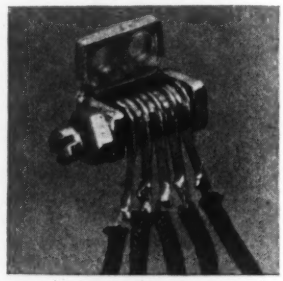
ground contacts, perform additional functions of alignment and polarization. Minimum air gap of ¼" is maintained between all contacts. Contacts are designed for use with a maximum wire size of #16 AWG. Available in two sizes, 18 contacts (RE18S) and 12 contacts (RE12S), new connector can also be supplied fitted with conventional straight type contacts (RE18) and (RE12). —*The Winchester Co., 6 East 46 Street, New York 17, N. Y.*

Please mention number 1136 when filling out card

Replacement Rectifier

New "universal" replacement copper oxide rectifier, designated as "Coprox Model CX2-E4U," offers a multitude of circuit variations depending on how two or more of its five

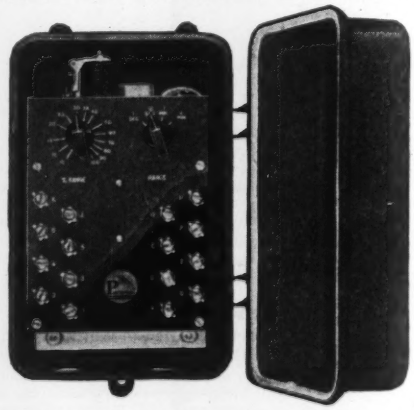


leads are used. As a half-wave rectifier it carries a rating of 6 or 12 volts a.c. at 3 milliamperes d.c. or 12 volts a.c. at 5 milliamperes d.c. As a double half-wave unit, it is rated at 6 volts a.c. for either 3 or 6 milliamperes d.c. In its full-wave back-to-back applications, unit's rating is at 6 or 12 volts a.c., at 5 milliamperes d.c. and as a full-wave bridge it is rated at 6 volts a.c., 5 milliamperes d.c. 3" flexible leads are color-coded and pre-soldered to prevent overheating during assembly. Any unused leads are simply clipped off after the circuit has proved satisfactory. Pellets are gold-coated to combat aging and instantaneous loads several times rated voltage or current can be handled.—*Bradley Laboratories, 82 Meadow St., New Haven 10, Conn.*

Please mention number 1137 when filling out card

Automatic Timer

New "Type 30HL1 Electronic Timer," for intervals from 1/20th second to four minutes, provides four basic types of timing: interval,



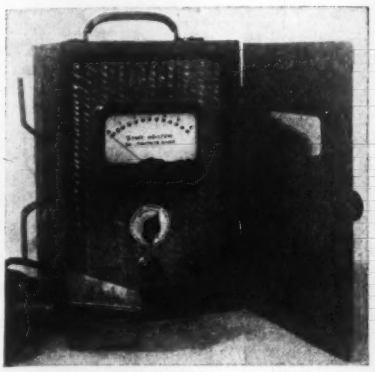
delayed action, automatic repeat, and programming, as well as many variations of these four fundamental types. All of these timing combinations may be utilized by changing external connections to terminal board. In addition, a maximum time interval selector switch provides for five time intervals. "Type 30HL1" is capable of timing any interval between 1/20th second and four minutes to an accuracy of less than 2%. Electric circuit is said to be self-compensating for changes in line voltage, so that accuracy does not change from day to day, nor will replacement of vacuum tube alter original

2% limit of accuracy variation. Either 115- or 230-volt 50-60-cycle supply line may be used.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Please mention number 1138 when filling out card

Moisture Meter for Concrete Sand

New moisture meter for concrete sand is electrical: its prod or pick-up is merely inserted in the sand to obtain a reading. De-

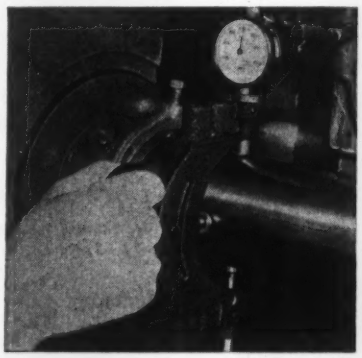


vice can be mounted in batching hopper to indicate continuously the percent of free-moisture. Installation is not involved: user standardizes his instrument for the particular sand he is using and instrument requires no further calibration. — *J. Thos. Rhamstine, Box 289, Harlingen, Texas.*

Please mention number 1139 when filling out card

Indicating Snap Gage

New "Decimatic Dial Snap Gage" has demountable heads and extension spacers. A single pair of heads and four extension

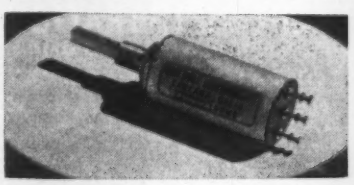


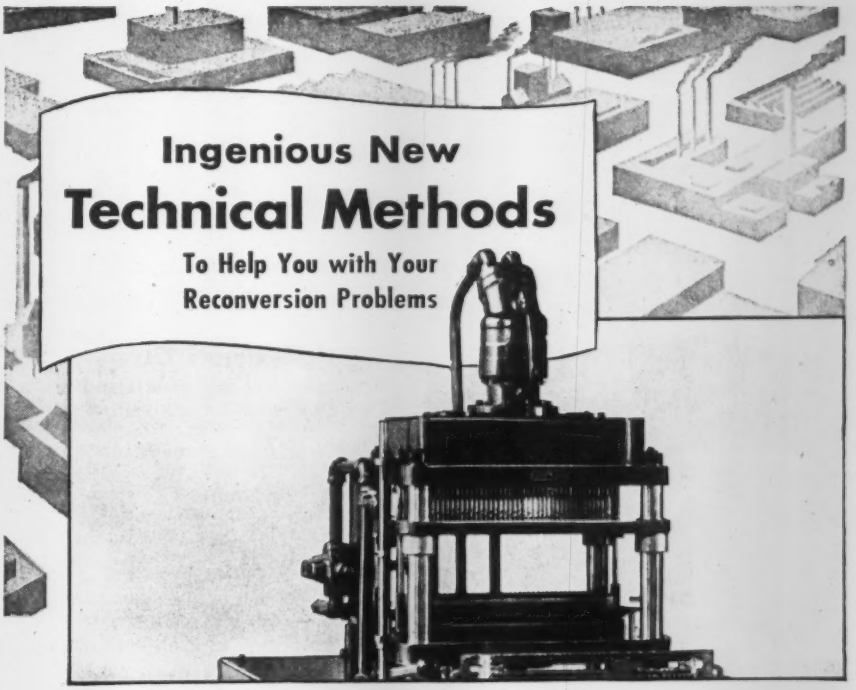
spacers of different lengths cover range of 4". Both gaging pins are surfaced with cemented carbide to reduce wear. Lower (adjustable) pin is flat; upper pin, which actuates indicator, has a spherical surface. The gage is operated by passing it over the work piece and noting the greatest deflection of the hand as the reading. Sets comprising a complete gage and three extra spacers are available and cover either range of 0 to 4" or 4" to 8".—*Standard Gage Co., Poughkeepsie, N. Y.*

Please mention number 1140 when filling out card

Voltage-dividing Resistor

New "Van Dyke Helical Potentiometer" is a linear wire-wound resistor of helical form, especially designed for flight test





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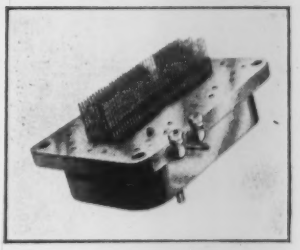

Zagar 220 Spindle Gearless Drillhead

The Zagar Gearless Drillhead can accommodate up to 400 drills in one head—drill up to 400 holes at one time! This revolutionary unit runs noiselessly and vibration-free on needle, tapered roller and precision ball bearings, and is lubricated by a patented automatic oiling system to insure trouble-free operation.

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Another time saver, as well as a help on a tedious job, is chewing gum. The simple act of chewing seems to make the work go faster, easier—helping to relieve worker's fatigue—so that a better piece of work can be turned out with greater safety. Wrigley's Spearmint Gum may be used even when both hands are busy—right where the work is being produced.

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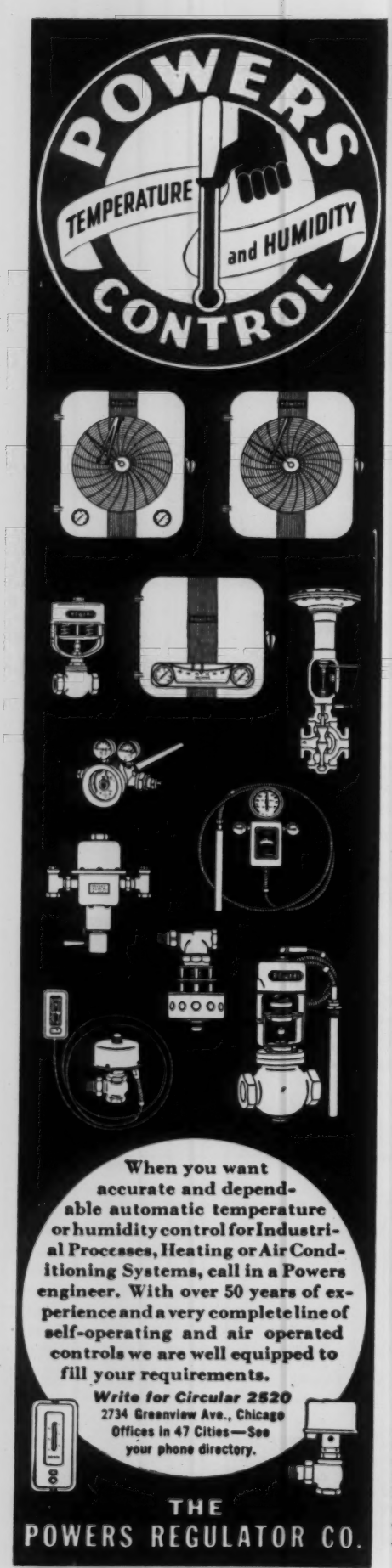

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and allied instrumentation work. Linearity of resistance is maintained by electronic control during winding process. Five- and ten-turn units are available. Body is 1" diam. and ⅞" base length with 0.1" added for each turn (standard 10-turn unit thus is 1⅞" long). Resistance values up to 3000 ohms per turn can be supplied with Advance wire; to 6000 ohms per turn in Nichrome. Normal resistance tolerance ±5%, linearity better than 0.5%.—*Van Dyke Instruments, P. O. Box IP 696, Tarzana, Calif.*

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Liquid Level Indicator for Steel Drums

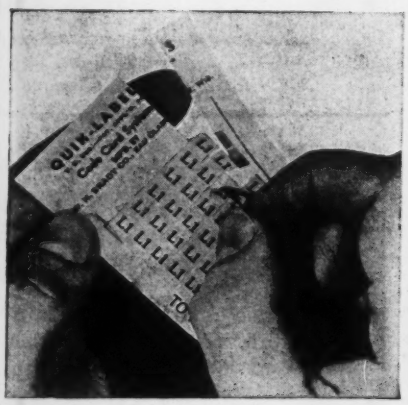
New "U.C." indicator, attached to 50- or 30-gallon steel drums, makes it easier to keep inventory, check and guard against

pilfering, and maintain a dependable reorder system: quantity of oil, solvent, or other liquid remaining in drum can be told at a glance. To install, screw Indicator into drum faucet opening, then screw faucet into opening on Indicator body; release locking device, and Indicator is ready for use. When drum is emptied, entire assembly is removed and attached to a full drum.—*U. C. Indicator Sales, 152 W. Wisconsin Ave., Milwaukee 2, Wis.*

Please mention number 1142 when filling out card

Identification Labels

New "Quik-Labels" speed up and simplify marking or coding of leads, harnesses, circuits, conduits, relays, coils, terminal boards,



etc. They stick without moistening to any round or flat surface, come on code cards ready for instant use. Labels are peeled from card by means of "Self-Starter Strip." More than 400 different code cards are available, including 14 colors. Special code cards can be designed.—*W. H. Brady Co., 2900-V Lindwood Ave., Milwaukee 11, Wis.*

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Journal of the Instrument

Editor, R. R. PROCTOR, 2213 Ridge Ave., Evanston, Ill.

SOCIETY OF AMERICA

Vol. 1 NOVEMBER 1946 No. 2

Editorial

PLANNING AHEAD

We are just discovering that in order to have a well-balanced ISA Journal, and at the same time not have to write everything ourselves from scribbled notes, memory and guesswork, it is going to require a little organization and a little pushing on our part. For example, this issue contains material submitted by 13 of the 23 Sections of ISA now in existence, whereas we should have all 23 Sections represented. We have discovered one reason for this, but it does not account for all the vacancies in the Section News Department. Through force of habit or lack of proper notification, many Section Secretaries and Correspondents sent their material directly to Instruments Publishing Company instead of to your new Editor. Thanks to our friend, Major Behar, a considerable portion of this reached us in time to make the deadline, but any other material which accumulated in Pittsburgh between the 16th and 23rd of October will have to wait until next month for publication.

Some of the Section News this time is untimely since it was received too late to be published in the October issue. However, it is printed herewith for several reasons, one of which is to show all correspondents, including the delinquents, the type of article we want in the Section News Department. (Note particularly the Charleston, Chicago, Kansas City and New Jersey write-ups.)

We would like to repeat our request of last month that each Section assign to some one the duties of correspondent, whose responsibility will be to submit *something* to us every month. The least that should be furnished is a report of the last meeting and the announcement of one or two coming meetings. It should be remembered that the deadline for material is the 15th of any month, and that the issue for which it is intended will usually appear on or before the 15th of the following month (barring strikes, strokes and breakdowns). For meeting announcements to be timely they should be in our hands at least two months in advance, if possible. Such notices, and only such notices, can still be published if they reach us by the 20th of the preceding month.

So that there may be (at least from the Editor's standpoint) some organization to the publishing of this Journal, it is planned to print the list of Section Correspondents in the very near future. If you want your Section represented on this list, please send us the name of your appointee as soon as possible. Also, in the interests of organization, it is tentatively planned to conduct the Journal on a departmental basis, and the following suggested outline should be a guide to all who are interested in seeing the Journal grow into a useful organ.

The departments now in the formative stages are as follows:

Editorial (Editorial comment, letters to the Editor, guest editorials, suggestions, and any other material which rightly belongs in this category).

Section News (Section activities, meeting announcements, local election results and appointments, personals, personnel items, etc.).

General News (Committee activities, joint meeting news outside of Section News activities, and other general-interest material).

Official (messages or bulletins from Officers or Executive Committee, advance notices of committee meetings and Directors' meetings, etc., official committee reports, financial statements, Secretary's messages, reports and requests, etc.).

Personal Column (Inter-Society transfers, promotions, changes of affiliation, employment, accidents, deaths, etc., not covered in Section News articles).

Technical (papers presented before Sections or at Conference Sessions, technical reports or articles written especially for the ISA Journal, etc.).

Special (biographies, historical or documentary articles, special features such as the Constitution or Constitutional amendments, etc.).

Miscellaneous (jokes, cartoons, and any other material which doesn't fit elsewhere in the above framework).

The above is not official nor permanent. It is just the way we have our eight "live material" folders marked in our briefcase! By the time we start getting enough material to overflow these folders, we hope to have had enough suggestions (from the Publications Committee, Executive Committee, and elsewhere) to create a more workable and possibly permanent departmental set-up. We need your help and suggestions on this also.

Since it has not been possible to go after all types of material at once, and also since we have barely got our editorial feet under us at this writing, this issue will not contain much more than Section News and a couple of editorial columns. However, it is planned to publish the Constitution and By-Laws very shortly, as well as Committee Reports of various sorts as soon as the committees start functioning. Also, some special features are in the offing, including a photograph and short biographical sketch of each officer and delegate. Guest editorials by the members of the Executive Committee are also being solicited for publication in a series very shortly.

This is only the beginning. With the cooperation of all concerned, including the Officers, Delegates and Journal correspondents of the various Sections, we can soon be "on-stream" with our Infant Journal, and can have a going concern ready to turn over to our successor when the time comes to employ a full-time Editor. —RRP

EDITOR'S NOTES

1. NO MORE CALENDAR

Unless strenuous objections are raised, the calendar as formerly used will no longer be a part of this Journal. In the interests of more efficient utilization of space, advance meeting notices will be included in the Section News articles as in this issue. If every Section correspondent will submit advance meeting notices, whether accompanied by any other material or not, that Section will be given space for said announcements in the Section News Department. The more information sent to us about Section activities, the more will be published.

2. ANOTHER FEATHER IN THE ISA HAT

Reports are still coming in on the success of the Pittsburgh Conference. "Testimonial letters," unsolicited and in fact unexpected, have been received by various officers of the Society, and most of them can be summed up by the following representative paragraph which was selected from one exhibitor's letter. We quote, ". . . It is only proper that I inform you of the reaction of representatives of this company who participated in the Exhibit to the arrangements which were made and the general atmosphere of the occasion. We have all felt that this was the finest and most carefully prepared occasion of this type in which we have participated for some time. Not only was the prior work and careful planning most evident in the smoothness with which everything moved but, additionally, the character of the exhibits and the attendance in all respects were superior to other similar exhibits in which we have participated." 'Nuff said!

3. OUR NEWEST SECTION

The South Texas Section, formerly the South Texas Instrument Society, was admitted to the ISA in October as the twenty-third Section of our organization. The Secretary is Mr. Homer C. Givens, The LaGloria Corporation, P. O. Box 637, Falfurrias, Texas. Further activities of this group, as well as a list of officers, etc., will be published in our forthcoming issues.

We take this opportunity to welcome the South Texas Section, and to express the hope that their affiliation with the Instrument Society of America will prove to be of mutual benefit.

—R. R. PROCTOR

News of Sections

BALTIMORE

(Latest unpublished material available)

At the May meeting of the Baltimore Section, the following officers were elected for the year 1946-47:

President: John F. Maienshein, Brown Instrument Co.

Vice-President: Henry Wolbert, Standard Oil Co. of New Jersey.

Secretary-Treasurer: Howard L. Halstead, Bethlehem Steel Co. Home address—45 Yorkway Road, Baltimore 22, Md.

Recording Secretary: Wilmer Clipper, Continental Oil Co.

Sergeant at Arms: Richard Nest, General Automatic Oil Burner Co.

Council: Fred Pullen, Earl Heden, Thomas Coyle, Frank Gregloit and Howard Reiner.

Following the election of officers, a very interesting inspection tour was made through the Calvert Distilling Co. plant at Relay, Md.

—FRANK RAGAN, Sec'y 1945-46

CHARLESTON

Two meetings within eleven days gave members of the Charleston Section considerable food for thought. On September 27, Senator Harley M. Kilgore addressed a joint meeting of the Charleston chapters of six national scientific and engineering societies, including the Instrument Society of America. In his talk, Senator Kilgore declared that the United States can no longer afford to depend upon the basic research of foreign countries, but that "we must develop our own basic researchers if we are to keep pace and assume leadership in scientific progress."

Such would be accomplished, he said, through enactment of the research foundation bill which he introduced to the 79th Congress. This bill was passed by the Senate, but failed to be reported out by the house committee. He said it would be brought up at the next session.

The six societies sponsoring Senator Kilgore's talk were, as previously reported briefly in these columns: The Instrument Society of America, The American Chemical Society, The American Institute of Chemical Engineers, The American Society of Civil Engineers, The American Society of Mechanical Engineers, and The West Virginia Society of Professional Engineers. The meeting was preceded by a dinner for the officers of the several societies. ISA was represented at the dinner by Messrs. C. B. Cochran, President, M. B. Lorig, Secretary, Ralph D. Webb, National Delegate, and Ammi Adler, Treasurer.

The regular October meeting of the Charleston Section was held October 7th at the Kanawha Hotel with approximately 85 members and guests in attendance. Speaking on the "Readability and Errors in Flow Measurement," Mr. Henry Stoll, Application Engineer, Taylor Instrument Companies, first explained the basic theory of flow, deriving his fundamental equation on the basis of simple energy analogies. In so doing he showed how differential is produced across an orifice, venturi or nozzle. Mr. Stoll then proceeded to explain and prove how errors enter and multiply in flow measurement.

Mr. Stoll's talk further analyzed the effect of pulsation on flow measurement, and covered the effects of other sources of error such as plate conditions, inherent meter inaccuracy, air in instrument leads (liquid flow), and high differential to pressure ratios (gas flow).

An enthusiastic discussion period followed Mr. Stoll's talk.

The meeting scheduled for Monday, Nov. 4, will cover "Mechanics and Economics of Centralized Control for Operating Units." Speakers will be Mr. F. H. Trapnell of E. I. duPont deNemours & Co., and Mr. C. B. Moore of Moore Products Co.

The following meeting will be held Monday, Dec. 2. The speaker is to be Mr. Walter P. Mills, Brown Instrument Co., who will talk on "Simplified Field Service of Electronic Instruments."

—M. B. LORIG, Sec'y

CHICAGO

At the regular meeting of the Chicago Section on Monday, Oct. 7, Mr. Carl E. Ohleiser of American Instrument Co., Silver Spring, Md., gave a very interesting and informative talk on the subject of "Electric Hydrometry for Measurement and Control." His talk, illustrated by slides, explained the principles underlying the variable resistance and bridge-type sensing elements used in humidity indicating instruments, and also showed how Electric Hygrometry in its commercial aspect became a direct off-shoot of RADIO SONDE as used by the Weather Bureau Meteorological Stations. A very interesting discussion period followed, during and after which Mr. Ohleiser demonstrated some of the sensing elements and instruments used in this field.

Preceding the technical part of the program, Mr. Earl Rieger, Chicago Section Delegate, reported on the Pittsburgh Conference and introduced (for the benefit of new members especially) Mr. J. B. McMahon and Mr. H. E. Ferguson, who were elected Vice-President and Treasurer, respectively, of the national organization. Mr. Rieger also announced that Mr. R. R. Proctor, Chicago Section President, had been appointed Editor Pro-tem of the ISA Journal section of *Instruments* magazine, and that Mr. Albert F. Sperry, national Past-President, had been appointed National Chairman of the 1947 Conference (Chicago) Committee.

Thirty-five members of the Chicago Section were in attendance at the Pittsburgh Conference, according to a report by our Membership Committee.

The November meeting is to be a joint session with the Northern Indiana Section at Phil Smidt's Restaurant in Hammond, at which a talk on "Latest Developments in Application of Electronics in Industry" is to be given by Mr. F. Roberson, Assistant Division Superintendent of Maintenance, Carnegie-Illinois Steel Corp., Gary, Ind.

The December meeting, scheduled for Monday, Dec. 2, at the Builders' Club in Chicago, will feature Mr. A. H. Shafer of the Foxboro Co., Pittsburgh, who will present "New Developments in Automatic Control Instruments."

—JOHN C. VAALER, Corr.

CLEVELAND

The next meeting of the Cleveland Section will be held on Wednesday, November 27th at the Cleveland Engineering Society. Dinner will be at 6:30 P. M. with the meeting starting at 8:00. Mr. William H. Haynie of the National Advisory Committee for Aeronautics will speak on "N.A.C.A. Gas Analysis Instrumentation for Aeronautical Engine Research."

DETROIT

(Received too late for the October issue)

The September meeting of the Detroit Section featured a talk by Mr. J. B. McMahon of Republic Flow Meters Co., Chicago, on the subject of "Flow Metering." While this topic has been covered extensively in numerous publications and discussions, Mr. McMahon presented it in a slightly different and interesting way by tracing the history of orifice metering from the days of the ancient Romans and the Maya Indians up to the present, and covered the work done in recent years by the AGA, ASME, the National Bureau of Standards and other investigators.

The technical, yet non-mathematical, part of Mr. McMahon's illustrated lecture summarized the principles of fluid flow and the factors which tend to complicate the simple basic flow equation. Among the measuring devices discussed were orifices, nozzles and venturi tubes, and their relative advantages and limitations were pointed out. The discussion following the talk was very lively, and tended to further prove Mr. McMahon's broad background in this field.

Mr. McMahon's talk was preceded by a short address by Mr. Walter Oliver, president of the Michigan Society of Quality Control Engineers, who introduced to the audience the interesting and relatively new method of statistical quality control.

Herb Barnum, one of the newly-elected Vice-Presidents of the ISA, presented a brief report on the Pittsburgh conference and exhibit.

Before and after the meeting, Mr. A. Satullo, local representative of the Brush Development Company, demonstrated their new Transient Recorder. This novel device proved very successful and it is planned to feature the demonstration of different types of apparatus at each of our subsequent meetings.

The next meeting of the Detroit Section, scheduled for Monday, October 21, at the Ethyl Corporation Research Laboratory, will be on the subject of "Sound and Vibration Analysis." The speaker is Mr. W. R. Saylor of General Radio Company.

—S. KULKA, Corr.

KANSAS CITY

At the September 10th meeting of the Kansas City Section, Mr. W. H. Steinkamp of the Brown Instrument Company, presented a very impressive talk illustrated by animated cartoons, which pleased everyone present. Mr. Steinkamp exhibited a very good sense of humor which contributed much to the evening's success.

The October 3rd meeting featured Mr. F. M. Stephens, Development Engineer, The Fluor Corporation, Ltd., Los Angeles, California, who spoke on "The Theory, Measurement and Control of Pulsation." The use of compression equipment at high rotative speeds and high operating pressures had made many of those present uncomfortably aware of the phenomenon called Pulsation, which arises like a spectre and imparts the shakes to piping, instruments, designers and operators. Mr. Stephens, who has spent many years in the laboratory and in the field studying this phenomenon, had practical suggestions for those interested in reducing noise and vibration and instrument cycling, as well as for those interested in improving measurement and control.

Immediately after Mr. Stephen's talk, Mr. Pat Miller of Panhandle Eastern Pipe Line Company, led a round-table discussion on the effects of pulsation on measurement and control.

On Monday, November 25, the Kansas City Section will be host to the Kansas City Section of the I.R.E. in the Main Auditorium, University of Kansas City, 5100 Rockwell Road. The meeting will start at 7:30 p.m. The speaker is to be Mr. Lawrence F. Parachini of the Weston Electrical Instrument Co., Newark, New Jersey, who will lecture on "Electrical Indicating Instruments." His discussion will cover the six basic electrical indicating mechanisms in general use, as well as the various accessories used with these basic mechanisms to indicate speed, temperature and current, both A.C. and D.C. Transparent cased models of the various mechanisms under discussion will be exhibited.

—OLIVER L. BOUTROS, Sec'y-Treas.

NEW JERSEY

The first meeting of the New Jersey Section's 1946 Fall season was held on October 1st. Through reports of those in attendance at the Pittsburgh Conference and Exhibit, the group of approximately 80 members and guests soon learned that the first ISA Conference was a success.

The evening's discourse was delivered by Mr. Allen L. Chaplin, a member of this Section. His subject, "Some Problems of Instrumentation in the Chemical Process Industry," in effect covered the whole field of instruments. Such a broad discussion might seem to be too encompassing for one evening's talk, but Mr. Chaplin brought up so many interesting aspects on each phase that he very ably covered his subject. He presented a unique chart grouping instruments by their major roles with respect to the whole plant's operation rather than by considering them solely for the "individual" function.

Mr. Chaplin also stressed the importance of instruments in continuous processes and the need for development of instruments to measure the build-up of impurities caused by re-cycled materials. Through his crystal ball he looked forward to the plant application of laboratory instruments which employ infra-red, ultra-violet and X-ray measurements in their operation.

The next meeting, scheduled for Monday, October 28th, is to be a joint meeting of the New Jersey and New York Sections, and which will feature a field trip through LaGuardia Airport.

The November meeting, also a joint meeting of the New Jersey and New York Sections, will be held at the Men's Faculty Club, Columbia University, New York City, on Wednesday, November 20. Dinner at 6:30, meeting at 8:00 p.m. Subject to be announced later.

—H. S. CLOSE, Sec'y

NEW YORK

The 42nd monthly meeting of the New York Section was held at the Men's Faculty Club, Columbia University, on September 30, 1946. About 50 members and guests attended the dinner, with about fifteen additional coming for the meeting.

Prof. Kayan, Section President, opened the meeting at 8:00 o'clock with a report on the very successful first annual ISA Conference and Exhibit held in Pittsburgh September 16th to 20th. He then called upon the Secretary to elaborate on the exhibits and sessions.

Mr. Haggerty announced the field trip to LaGuardia Airport as the October meeting to be held on the evening of the 28th. Supper at $2.50 per person will be served at the field at 6:30 p.m.

The meeting was then turned over to the technical chairman of the evening, Mr. Schofield, who in turn introduced the speaker, Mr. Edward Barlow of the Engineering Laboratory, Sperry Gyroscope Company, New York. Mr. Barlow then presented a very interesting talk on the elementary principles of "Doppler Radar" and its advantages over the standard systems of radar. Demonstration apparatus was turned on and numerous tests were made to show its ability to detect both high and low speeds in moving objects and its sensitivity in detecting motion with a small displacement.

The audience then gathered around the apparatus and speaker to ask more advanced questions and to try out the equipment for themselves. The meeting was adjourned at 9:45 p.m.

—CHARLES D. COREY, Sec'y

PITTSBURGH

October 28th meeting, "Manometer Applications in Industry," by Mr. A. A. Hejduk, Meriam Instrument Co., Cleveland, Ohio.

November 25th meeting, "Hydrogen Ion Measurement," by Dr. E. D. Haller of National Technical Laboratories, Bethesda, Md. Dinner at 6:30 p.m., meeting at 8:00 in the Blue Room of the Roosevelt Hotel.

—L. M. SUSANY, Sec'y

ST. LOUIS

The St. Louis Section held its regular meeting on Monday, September 30, 1946, at the New York Hotel in St. Louis. The Pittsburgh meeting was discussed by Messrs. W. E. Boyle and R. H. Munch, who were among the St. Louis Section members who attended the meeting. It was announced that Dr. Munch, Section Chairman, had been elected one of the Vice-Presidents of the National Society. It was also announced that a number of committees to deal with formulation of recommended practices were being organized by the ISA, and that all members interested should communicate with the chairman of the Recommended Practices Committee (Ed. note: F. H. Trapnell, Philadelphia Section) or with the local Secretary.

The speaker of the evening was Mr. Harry H. Hilliker, Senior Development Chemist of the National Lead Co., Titanium Division, St. Louis. His subject was "Description of the X-Ray Spectrometer and Its Applications." The instrument discussed was the "North American Philips X-Ray Spectrometer," with application to the study of the crystal structure of solids. Mr. Hilliker sketched the early work done with solid crystals of sodium chloride, and explained that X-rays must be used to study such crystals because the wavelength of the X-rays approximates the distance between the faces of the smallest obtainable crystal of material. Therefore, interference can be obtained from the rays reflected from the several sides of the crystal and the measurements and characteristics of the crystal structure can be investigated.

With the aid of a curve-drawing recorder, a complete analysis of a given specimen can be made by this method in 90 minutes, whereas the standard photographic procedure requires 8 hours. Mr. Hilliker stated that the instrument had been used commercially to improve the quality of pigments and fibers and to obtain a much better product as a result.

Many questions followed the address, and Chairman Munch commented that X-ray studies provide powerful methods of fingerprinting materials, and that while still in the laboratory stage, the method would no doubt soon go into the plant to improve the quality of many products.

Attendance at the meeting was approximately 60 members and guests.

The next meeting of the St. Louis Section is to be held on October 28th at the York Hotel. Two speakers are scheduled—Mr. L. C. Lodge, speaking on "German Guided Missiles," and Mr. O. G. Forcade, whose subject is "Refinery Maintenance of Pressure Type Thermometers."

The November meeting will be held on Monday, November 25th. The speaker will be Mr. C. W. Parsons of Republic Flow Meters Co., who will discuss "Measurement and Control of Difficult Fluids by Force Balance." Dinner at 7:00 p.m., meeting at 8:00 at the York Hotel.

—H. E. ZEFFREN, Sec'y

SOUTHERN MICHIGAN

(Received too late for the October issue)

The Southern Michigan Instrument Society held its first meeting of the 1946-47 season at the Park American Hotel in Kalamazoo on Sept. 11. Following the dinner, attended by about 30 members and guests, Mr. Glen Miller of the Kellogg Company, Battle Creek, introduced the speaker, Mr. Ken Mead of Allen Electric Co., who presented an illustrated talk on "The Theory, Design and Production Techniques of a Modern D'Arsonval Type D. C. Milliammeter."

Following the program, a short business meeting was held at which Presi-

dent Wade Allen announced a paid-up membership of 29 as of this date. Mr. Glen Miller was appointed Vice-President to complete the term of office which Mr. Fred Brydges, General Foods Corp., was unable to assume. A discussion of the national organization known as the Instrument Society of America followed, and a unanimous vote was cast in favor of making application for affiliation with the ISA. Local Section By-Laws which would conform to the ISA Constitution were read and accepted, and the officers, Wade Allen, President, Glen Miller, Vice-President, and Ken Mead, Secretary, were appointed as delegates to the ISA Conference and Exhibit in Pittsburgh September 16-20 to make the necessary arrangements for the group to become a Section of the ISA. The meeting then adjourned.

The October 9th meeting of the Southern Michigan Section of the ISA was held at the Kellogg Cafeteria in Battle Creek, and was attended by about 40 members and guests. Following the dinner, Mr. Oliver Wood of the Upjohn Company, Kalamazoo, introduced the speaker, Mr. J. Dunlap of the Brown Instrument Company, who gave a very interesting talk on "Fundamentals of Pyrometry." His talk was illustrated by slides which were both humorous and illustrative. After Mr. Dunlap finished, Mr. Jack Richardson, also of Brown Instrument Co., conducted a question and answer period.

A short business meeting was then called and several questions which had arisen as a result of the organization's recent affiliation with the ISA were discussed and referred to appropriate committees.

Mr. Glen Miller of the program committee announced that tentative arrangements have been made for the November 13th meeting, to consist of a dinner meeting and a field trip through the Morrow Plant at Comstock. This plant is one of Consumers Power Company's largest and most modern steam generating plants. Notices of the details are to be sent out later.

—KEN MEAD, Corr.

WASHINGTON

(Received too late for the October issue)

The 24th meeting of the Washington Section, ISA, was held at the Potomac Electric Power Company Auditorium on September 25, 1946, with a short business session starting at 7:30.

After the meeting was called to order by the Chairman, Dr. Windenburg, Mr. W. A. Wildhack, our National Delegate, presented a report on the Instrumentation Conference and Exhibit held in Pittsburgh September 16-20. It was announced that the Washington Section was inviting the National Meeting and Exhibit to Washington for 1948.

It was also announced that the next meeting of the Washington Section would consist of a tour of the David Taylor Model Basin.

The speaker of the evening, Mr. Howard K. Morgan, Chief Development Engineer of Bendix Radio Co., Baltimore, was then introduced, and his paper on "Navigational Instrumentation" was both interesting and informative. Forty persons were present at the meeting.

The 25th meeting of the Washington Section will be held Monday, October 21st in the PEPCO Auditorium. A business meeting at 7:30 p. m. is to be followed by a talk on the "Brown ElectroniK Potentiometer" by Mr. W. P. Wills, Director of Research and Development of the Brown Instrument Co., Philadelphia, Pa. The previously announced tour of the David Taylor Model Basin will be held at 9:30 a. m. on Wednesday, Oct. 23.

All meetings of the Washington Section of the ISA will be held on the third Monday of each month, November (1946) through May (1947), except the January meeting, in the PEPCO Auditorium. The January meeting is the annual dinner and the date will be announced later.

—G. M. ROLLS, Corr. Sec'y.

WAYNE COUNTY

At the September meeting of the Wayne County Section, Mr. E. D. Jackson of the Coon De Visser Company gave a talk on "Gyroscopes" and showed two sound motion picture films on gyro flight instruments and the manufacture of gyro-compasses for ocean liners. He illustrated his talk with actual models and typical instruments, and answered numerous questions for the members of the interested and very appreciative audience.

Several members who had attended the Pittsburgh Conference and Exhibit then gave short talks and reports. The Wayne County Section expects to turn out in much larger numbers next year.

The next meeting, scheduled for October 28th, at the Presbyterian Church in Wyandotte, will be a panel session conducted by Mr. H. H. Barnum, National Delegate of the Detroit Section and Vice-President of the ISA. The subject for discussion will be "Process Control Terminology."

—JOHN MACPHERSON, Pres.

LOUISVILLE

A meeting to consider the formation of an I.S.A. Section was held Armistice Day, November 11th, at the Seagram & Son Auditorium, Louisville, Ky.

Temporary officers were elected as follows: Temporary Chairman, E. H. C. Brown, Jos. B. Seagram & Co.; Temporary Secretary, S. W. Hawkinson, Brown Instrument Co., 633 S. 5th St., Louisville, phone Wabash 6075.

Another meeting has been scheduled for 8:00 p.m., Dec. 10th, at the Seagram & Son Auditorium. Anyone in or near Louisville, interested in this movement, is cordially invited to attend.

ISA
Employment Service

In printing these announcements the Society assumes no obligation as to responsibility of employers. Those replying to announcements should include two copies of their reply. When testimonial documents are to be included, copies of such documents and *not* the originals should be sent. The Society regards acknowledgment by employers of all applications as an act of courtesy but can assume no responsibility for their failure to do so. Address all replies to Employment Registration Committee, Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.

—C. F. GOLDCAMP, *Chmn. Employ. Reg. Com.*

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DOCTORATE in some branch of physics or biophysics, preferably with a minor in some field of biology. Experience in radiation and optics desirable. Should have 3 or 4 years post-doctorate experience in research.

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ELECTRONIC SCIENTISTS and Engineers of all grades (salaries $2600 to $8000). Education: college degree in physics, mechanical engineering, electrical engineering. Positions involve research and development to pilot model stage of complex ordnance devices. Box 2.

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CHEMICAL, MECHANICAL or Electrical Engineers for application of instrumentation to chemical processes involving the study of processes, the selection and preparation of specifications for the proper instrumentation, and assistance in starting up new operations which are controlled automatically. Open to young men with limited experience and to men who have had a considerable period of service with a process industry or with an instrument manufacturer where there has been opportunity for study of instrumentation as applied to the process industries. Box 3.

. . .

CHEMIST, PHYSICIST or Engineer for development of specialized measuring devices for applications to the food process industry, and for which there is no available commercially made instrument. Work would involve studies of process variables to determine suitable measuring criteria and the development of suitable industrial instruments for making these measurements. Box 4.

. . .

INSTRUMENT SUPERINTENDENT to take full charge of instrument department in large chemical plant. Box 5.

. . .

ELECTRICAL ENGINEER for design, development and production of industrial instruments. Should have the ability to supervise other employees where necessary and should be energetic and willing to work for results as well as for his own advancement. Box 6.

. . .

PHYSICIST with graduate studies and experience to work in connection with design, development and production of aeronautical instrumentation. Box 7.

. . .

ELECTRONICS ENGINEER or Radio Engineer for research on unconventional applications of audio frequency circuits and design of portable instruments for blind guidance. Box 8.

. . .

TECHNICALLY TRAINED MAN to operate an X-ray diffraction unit and to supervise electron microscope studies with particular interest in the structure of manganese dioxide and similar semiconductors. Box 9.

. . .

GRADUATE ENGINEERS for work in an engineering squad on instrumentation and process controls in the chemical industry. Box 10.

. . .

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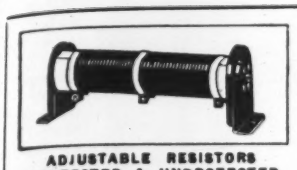

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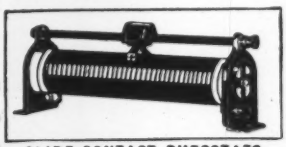

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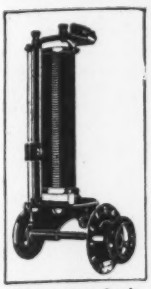

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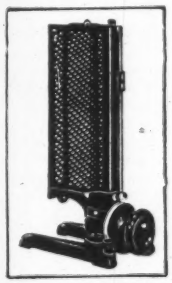

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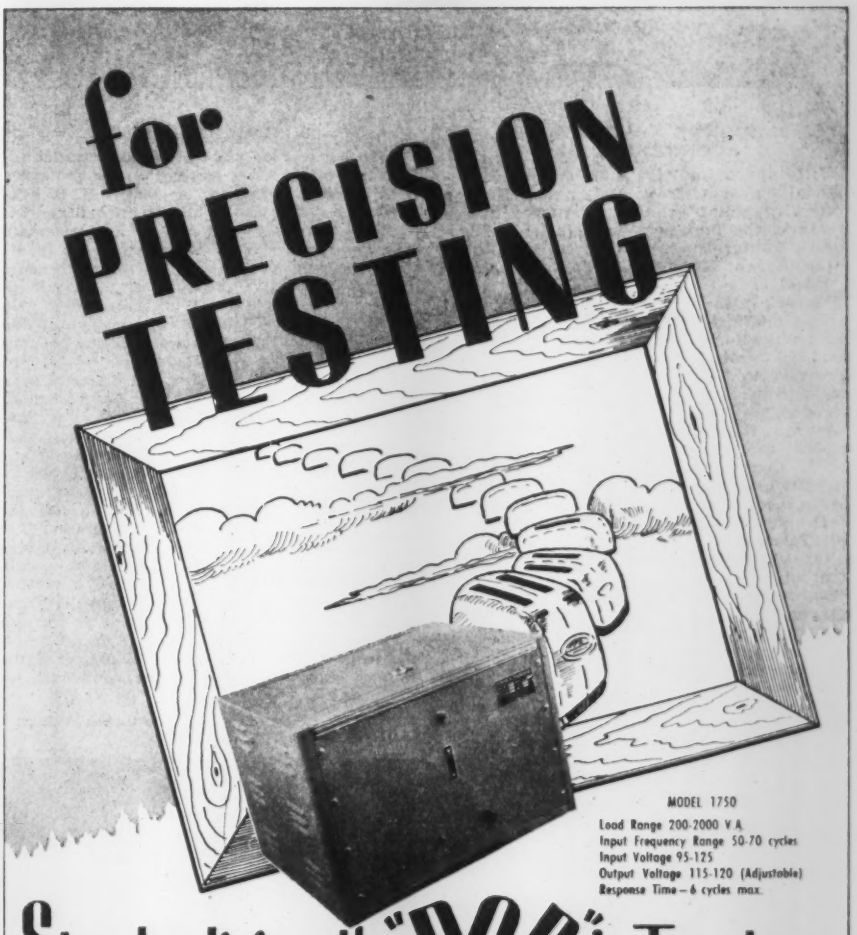

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Technical Society News

NATIONAL ELECTRONICS CONFERENCE

With approximately 2500 engineers, industrialists, educators and research men from throughout the United States in attendance, the first post-war National Electronics Conference was held at the Edgewater Beach Hotel, Chicago, on October 3, 4 and 5.

Featuring the presentation of technical papers dealing with recent developments and applications in the field of electronics, the 1946 meeting was acclaimed by many delegates as "one of the most highly successful conferences, from every aspect, ever attended."

Among the ranking speakers who addressed the three-day meeting were Dr. E. U. Condon, director of the National Bureau of Standards, Dr. Frederick L. Hovde, president of Purdue University, Dr. J. O. Perrine, assistant vice-president of Bell Telephone Laboratories, and Dr. C. G. Suits, vice-president of General Electric Company.

Eighteen technical sessions were held, with more than sixty prominent electronics men from research and industry presenting papers on such diversified subjects as television, spectroscopy, infrared and microwave systems, industrial applications, air navigation systems, theoretical developments, electronic instrumentation, induction and dielectric heating, antennas and wave propagation, FM, radio relay systems, recording and facsimile, microwave generators, and nuclear physics.

A wide range of exhibits, consisting largely of educational approaches to various electronic subjects and recent electronic developments, aroused considerable interest among delegates. Nearly seventy manufacturers of electronic equipment in a wide range of fields were displayers.

AKRON INSTRUMENT SOCIETY

The Akron Instrument Society held its first meeting of the '46-'47 season on Sept. 24th, at Riley's Tavern, where 52 members and guests were served T-bone steaks to their great appreciation.

Following a brief business meeting, President Luther introduced the speaker for the evening, Victor J. Head, Fluids Research Engineer, Fischer & Porter Co., whose topic was, "Rotameters, from a Slow Leak to a Hurricane." Mr. Head discussed the effects of inertia, viscosity and elasticity in fluid measurements and showed pictures of various types of floats in which one or more of these effects were used and the effects of the others minimized. One of his slides showed a float designed for flows as low as 0.8 cc./min. (a slow leak), another, one for 10,000 cfm. ("a small hurricane"). Mr. Head also described a new float, operating on the "viscous theory," which he stated had been successfully used on fluids with viscosities up to 100,000 centipoises, ("pure goo"). Also mentioned by him was a float designed under the "elastic theory" and its possible uses as primary standard for calibration of other instruments or as a metering method for very large flows.

During the question period following, Mr. Head answered a question regarding the use of the Rotameter with opaque fluids by describing the bead-guide tube especially suited to such service.

President Luther expressed the thanks of the Society to Mr. Head for his informative and entertaining discussion.

—FRED APPEL, JR., *Secretary*

AKRON INSTRUMENT SOCIETY

The October meeting was held at Riley's Tavern, where 48 members and guests partook of big steak dinners. Several more came for the meeting.

Several clarifying amendments to the constitution and by-laws were adopted at the business meeting. R. N. Vaughn was elected treasurer to fill the unexpired term of L. H. Smith, who left us for Birmingham, Ala. D. M. Yoder and A. H. Richard were added to the Executive Board.

The speaker for the technical meeting was W. H. Pugsley, Manager of Engineering, Hays Corp., whose subject was "Automatic Combustion Control." Mr. Pugsley explained the fundamental requirements for proper operation and efficiency and the methods used by his company to meet these requirements. He stressed the need for dependability of equipment and for accuracy of measurement, coördination of the readings and power to translate the impulses into results. Mr. Pugsley explained the application of control to various types of fuel-burning equipment.

Answering questions, Mr. Pugsley stated that on ball-mill jobs, air control is important and must be considered in layout. It may be necessary to measure air at different points. The control system must be engineered on any job and must be built to be readily tuned to conditions. Both speed of fan and damper control may be needed if operation involves wide load changes.

Great interest was shown in Mr. Pugsley's presentation, the second in the excellent series lined up for this year for the Akron society.

Next meeting—November 26th at Guggenheim Institute. Speaker—Mr. Herman, Taylor Instrument Co.—"Air Operated Controls." No dinner, meeting at 7:30 P. M.

—FRED APPEL, JR., *Secretary*

BOSTON ORGANIZER

"My first real job was that of Instrumentician." Few men can say that today when the profession is in its infancy, and one of them is H. S. Fairchild whose first responsible job in industry was that of Instrumentician at the Aruba (D. W. I.) Refinery of the Standard Oil Co., from 1938 to 1940. From 1940 to 1943 he was Instrument Engineer at the Marcus Hook Refinery of the Sun Oil Co., and since 1943 he has been with E. B. Badger & Sons Co. as Equipment Engineer, specializing in . . . (one guess!). He became an *Instruments* subscriber while at the Aruba Refinery in 1939; a charter member of the Philadelphia Instrumentation Society (now Philadelphia Section) while at the Marcus Hook Refinery in 1941, a member of the St. Louis Section last year and the Technical Speaker at that Section's December meeting (see January '46 *Instruments*). Last month, with the help of other enthusiasts, he organized the Boston Instrument Society. (See news item on this page.)

BOSTON INSTRUMENT SOCIETY

On Thursday, October 3, sixty-five men interested in instrumentation met at the Engineers Club in Boston, to formulate plans for a Boston Instrument Society. The group consisted of Instrument Engineers, Sales Engineers, and Maintenance Engineers from various chemical and petroleum companies, instrument manufacturers and processing plants in the Greater Boston area.

The temporary officers are: President, H. S. Fairchild; Secretary, C. J. Nazzaro; Treasurer, G. L. Seavey.

Program Committee: Ray Hoffman (Colonial Beacon Oil Co.), Warren Priest (Mason-Neilan Regulator Co.), Arthur Holmes (E. B. Badger & Sons Co.), James Russell (Stone & Webster), Allen Ungarro (Engineering Corp.).

Membership Committee: J. H. Condon (Instruments Publishing Co.), J. Melcher (Leeds & Northrup), K. E. Hart (Taylor Instrument Co.), J. Price Fisher Governor Co.), Edward F. L'Antigua.

Programs for future meetings were discussed and the suggestions enthusiastically received.

Those interested in joining should get in touch with H. S. Fairchild, E. B. Badger & Sons Co., 75 Pitts St., Boston. The society is independent; it rests entirely with those who join it whether it will or will not affiliate formally with a National organization.

—J. H. CONDON

Group at Boston organization meeting.

HARTFORD SOCIETY FOR MEASUREMENT AND CONTROL

At our annual meeting, May 21, 1946, the Society voted to become affiliated with the American Society for Quality Control. This matter had received considerable attention by the Executive Committee, and it was felt that there was sufficient interest in quality control to warrant bringing this matter to the attention of the Society. Being affiliated with the American Society for Quality Control does not affect the local Society's identity or autonomy, and membership in the ASQC is left entirely up to the choice of each of the local members.

At the annual meeting, the election of officers resulted as follows:

Chairman, William H. Gourlie; Vice Chairman, Joseph J. Ferri; Treasurer, Donald Collins; Secretary, Archie McDougall (Pratt & Whitney Aircraft Corp., East Hartford, Conn.).

The following committee chairmen were appointed by the newly elected chairman: Constitution and By-Laws, Raymond K. Hellman; Membership, Dean Ayer; Publicity, Gus Manke; Program, Joseph J. Ferri; Entertainment, Carl Moeller; Attendance, Bob MacGregor; Advisory Committee, Stanley Johnson.

Our Program Committee has completed its schedule for the entire season; meetings will all take place at the City Club, Hartford, Conn., the third Wednesday of each month, at 8:00 p. m., preceded by a dinner meeting at 6:30 p. m.

First meeting of the season will be held October 16th. The speaker will be Adam Gabriel, Vice President of Acme Industrial Co., Chicago, Illinois, and his subject will be "Light Waves and Their Uses in Shop Measurement."

At the November 20 meeting, J. H. Brown of the Westinghouse Corp. will speak on "Practical Applications of Quality Control."

—G. L. MANKE, *Ch. Publ. Com.*

INDIANAPOLIS TECHNICAL INSTRUMENT SOCIETY

The regular meeting of the Indianapolis Technical Instrument Society was held Tuesday, October 1. Victor P. Head of Fischer & Porter Co. gave a talk, "Flow Rate Measurement Enters a New Technical Era," which brought forth a very lively discussion period. This was essentially the same paper presented by Mr. Head at the Pittsburgh Conference with most of the mathematics omitted and was very well received by our group.

The speaker for our November meeting will be Mr. Harvey P. Rockwell, Jr. of the Rockwell Engineering Company, whose subject will be "Instrumentation in Photography."

The December meeting will be devoted to business during which the membership will vote on joining the ISA. Entertainment will be furnished by one or two short films.

—MORRIS UNDERWOOD, *Sec'y-Treas.*

WHITING INSTRUMENT MEN'S GUILD

The Whiting Instrument Men's Guild resumed monthly dinners and meetings at the Illiana Hotel on Sept. 25, 1946. The speaker was J. Connelly of Foxboro Co. The subject was fundamentals of instrumentation for the benefit of new instrument men.

New officers were on their first assignment: Charles F. Schweikert, Pres.; John Minsberg, Corr. Sec'y; Nick Scholl, Treas. John Cengel was Technical Chairman.

Next dinner meeting will be held on November 27 at Phil Smidt's Restaurant with Mr. Cohen of Leeds & Northrup lecturing on "Maintenance of L & N Temperature Recorders and Controllers."

—JOHN F. MINSBERG, *Corr. Sec'y*

FAIRMONT, W. VA.

The regular bimonthly meeting of the Westinghouse Technical Society was held October 14, 1946, at the Presbyterian Church in Fairmont. Members of the West Virginia Society of Professional Engineers were also in attendance.

After the dinner, M. F. Behar, the guest speaker, presented his talk on "Fundamentals of Instrumentation." Mr. Behar, the father of the organized science of Instrumentation, outlined the fundamental concepts of this technology. The engineers heard Mr. Behar explain some of these principles of instrumentation by using various phases of temperature measurement as examples. The lecture was illustrated by slides and "moving pictures" (animated diagrams).

Following the question period, a business meeting was called by the President of the Westinghouse Technical Society.

—CHAS. H. JOSEPH, JR., *Chairman, Publicity & Public Relation Committee.*

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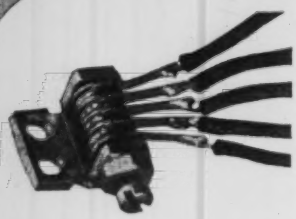

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Pre-soldered leads to prevent overheating during assembly and other Bradley features are embodied in this useful model, which offers 3 rating ranges as a half-wave, 2 as a double half-wave, 2 as a full back-to-back, and one as a full wave bridge.

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Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 711.

N-454 **Tachometer Test Stand.** 4-page 8½" × 11" bulletin pictures and describes "Model 1810 Tachometer Test Stand" with five drive outlets and a stroboscopic master for high accuracy checks at every 100 rpm. indicated speed. Ideal Laboratory Tool & Supply Co., 3619 Evans Ave., Cheyenne, Wyo.

N-455 **Altimeter Test Unit.** 8-page 8½" × 11" Bulletin 26 pictures and describes "Model A-900 Altimeter Test Unit" for use with a primary standard absolute pressure gage for checking and calibrating altimeters and rate-of-climb indicators. Meriam Instrument Co., 10958 Madison Ave., Cleveland 2, Ohio.

N-456 **Soil Moisture Meter.** 2-page 8½" × 11" bulletin pictures and describes the "Rhamstine Soil Moisture Meter" for determining the degree of available moisture in soil. J. Thomas Rhamstine, Box 289, Harlingen, Tex.

N-457 **Pilot Piston Control Valve.** 12-page 8½" × 11" Bulletin 501 pictures and describes "Belfield Pilot Piston Control Valve," a small wide-range diaphragm motor control valve. Includes flow characteristic curves, mechanical characteristics, dimensional drawings, etc. H. Belfield Co., 435 N. Broad St., Philadelphia 23, Pa.

N-458 **Small Rotameters.** 4-page 8½" × 11" Catalog Section 31-E pictures and describes "F & P Junior Rotameters" for flows from 3.5 cc./min. to 0.1 gpm., and the "C-Clamp Rotameters" for replacing bubbler-type liquid-filled meters. Fischer & Porter Co., Hatboro, Pa.

N-459 **Soil Resistivity Meter.** 2-page 8½" × 11" Bulletin 211 pictures and describes "Model 243 Soil Resistivity Meter," a portable instrument for rapid determinations, calibrated in ohms per cubic centimeter. Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.

N-460 **Universal Timer.** 4-page 8½" × 11" bulletin, pictures and describes the "GraLab" universal timer for automatic visual or audible timing in minutes and seconds. Gray Laboratory & Mfg. Co., 43 W. Apple St., Dayton 2, Ohio.

N-461 **"Weston Engineering Notes."** 8-page 8½" × 11" Vol. 1, No. 2 of this house organ contains articles on a number of maker's new instruments, including: Conduction Grid Current Megohmmeter, Single Point Potentiometer, etc. Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

N-462 **Electric Motor Controls.** 72-page 8½" × 11" catalog is composed of a number of bulletins picturing and describing maker's line of manual, automatic and pedal controls for electric motors. Furnas Electric Co., Batavia, Ill.

N-463 **Production Counter.** 2-page 8½" × 11" bulletin pictures and describes the "Shadowcount," an electronic instrument for high-speed production counting. The Autotron Co., Danville, Ill.

N-464 **Truck-operation Recorder.** 4-page 8½" × 11" bulletin pictures and describes "Model T-R-T Servis Recorder" which gives a three-day record of time truck is in operation. The Service Recorder Co., Cleveland, Ohio.

N-465 **Counters.** 8-page 8½" × 11" Bulletin Form. 50, pictures and describes a line of counting, timing and recording devices, both mechanical and electrical. Production Instrument Co., 706 W. Jackson Blvd., Chicago 6, Ill.

N-466 **Panel-type Tachometer.** 2-page 8½" × 11" bulletin pictures and describes "Ideal" panel-type tachometer for use where instrument panel is mounted far removed from machine. Ideal Industries Inc., 1420 Park Ave., Sycamore, Ill.

N-467 **Bibliography on Spectrography.** 16-page 6" × 9" booklet contains a general reference list of articles and books on spectrography. Eastman Kodak Co. Rochester, N. Y.

N-468 **Z-angle Meter.** 4-page 6" × 9" bulletin pictures and describes the "Type 310-A Z-angle Meter" for measuring impedance in ohms and phase angle in degrees. Technology Instrument Corp., 1058 Main St., Waltham 54, Mass.

N-469 **Test and Calibration Chambers.** Four 4-page 8½" × 11" folders picture and describe maker's line of test and calibration chambers, including: Utility Units, Relative Humidity Simulation Units, Altitude Units, and Laboratory Units. Bowser, Inc., Refrigeration Div., Terryville, Conn.

N-470 **Production Counters.** 12-page 8½" × 11" Catalog No. 50 pictures and describes line of pick counters and industrial counters for textile mills. Durant Mfg. Co., 1929 N. Buffum St., Milwaukee 1, Wis.

N-471 **"The Ohmite News."** 2-page June-July issue of this house organ contains a number of short items and descriptions of several of maker's products. Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44 Ill.

N-472 **"The Burrell Announcer."** 16-page 7½" × 8½" issue of this house organ, designated No. 46-7-23, contains short articles on a number of products available from this laboratory supply house. Burrell Technical Supply Co., 1935-42 5th Ave., Pittsburgh 19, Pa.

N-473 **"The C-D Capacitor."** 16-page 5½" × 8¼" Vol. 11, No. 6 of this house organ contains the first part of an article entitled "Television Receiver Antennas," by R. B. Garwood, reprinted from *Service* magazine. Cornell-Dubilier Electric Co. Hamilton Blvd., South Plainfield, N. J.

N-474 **Micro Switches.** 104-page 8½" × 11" Catalog 61 pictures and describes maker's complete line of "Micro Switches" and illustrates many uses for these products. Micro Switch, Div. of First Industrial Corp., Freeport, Ill.

N-475 **Electronic Level Control.** 6-page 3½" × 8½" Bulletin E100 pictures and describes maker's Electronic Level Control for maintaining the level of any liquid or conducting solid in any type of container. Trimount Instrument Co., 37 W. Van Buren St., Chicago 5, Ill.

N-475a **Vacuum Thermocouples.** 12-page 4" × 6¾" catalog pictures and describes 86 standard types and ranges of vacuum thermocouples. Included are the Standard Line, W-line, High-speed Line, 25-millivolt Line, 50-millivolt Line, and Ultra-high Frequency Line. American Thermo-

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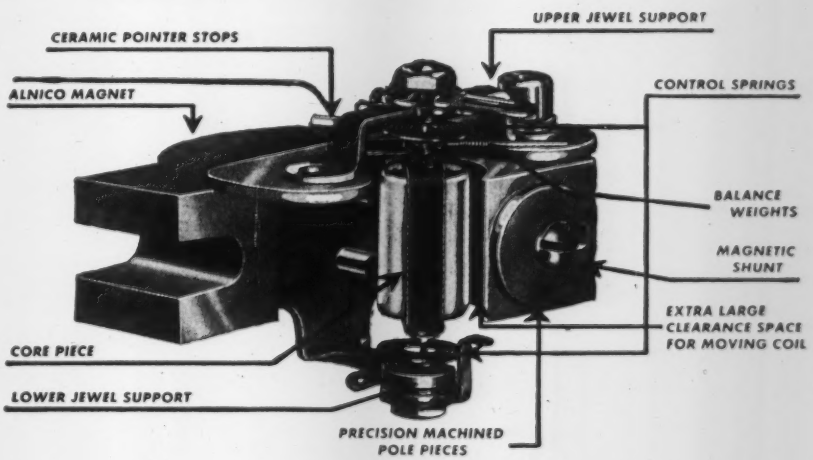

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N-477 **Polarograph.** 6-page 8½" × 11" folder illustrates and describes instrument for polarographic method of analysis based on interpretation of current-voltage curve characteristics of a solution electrolyzed with the dropping-mercury electrode. E. H. Sargent & Co., 155-156 E. Superior St., Chicago 11, Ill.

N-478 **Motion Pictures.** 28-page catalog GES-40-2J lists, with instructions for ordering, the company's films available for loan (free) to industrial organizations. General Electric Co., Schenectady, N. Y.

N-479 **Temperature Controls.** 8-page 8½" × 11" Bulletin No. 340 describes and illustrates throttling gas controls, quick-acting controls, stuffing boxes, indicating and non-indicating temperature controllers, dial thermometers, temperature recorders, time delay relays, and "Saf-T-Flame" gas pilot. The Partlow Corporation, New Hartford, N. Y.

N-480 **Self-operating Temperature Regulators.**. 2-page Bulletin No. 1000 describes and illustrates "Series 90000" self-contained and self-operating regulators, suitable for hot-water tanks, pasteurizers, storage rooms, plating tanks, cookers, feed-water heaters, etc. H. O. Trerice Co., 1420 W. Lafayette Blvd., Detroit 16, Mich.

N-481 **Variable-voltage Transformer.** 12-page 8½" × 11" Bulletin No. 149A illustrates and describes the "Powerstat" variable autotransformer for obtaining continuously-varied output voltage from a-c. power lines. Particularly adapted to control of electric furnaces, motors, lighting, laboratory and shop line voltage control, radio transmitters, etc. Superior Electric Co., Bristol, Conn.

N-482 **Instruments and Controls for Process Industries.**. 8-page 8½" × 11" Bulletin 17 lists the various types of Bailey air-operated controllers and the measuring components which may be used to actuate automatic control. Brief application data in the form of sizes, pressures and ranges are included. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio.

N-483 **Time Switches.** 4-page 8½" × 11" Bulletin T-55 lists time control service under three distinct classification: standard line, complete systems, and low-cost time switches. Six representative examples of time switches illustrate size limitations, switching action, contact rating, mounting methods, adjustability and other desired features. Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.

N-484 **Course Counter for Knitted Fabric.** 4-page 8½" × 11" Bulletin illustrates and describes a scientifically correct method of measuring knitted fabric. The Course Counter instrument gives a positive control of stitch size for uniform knitting on every machine section and is independent of weather and yarn conditions. Fidelity Machine Co., 3908-18 Frankford Ave., Philadelphia, Pa.

N-485 **Layout Protractor.** 2-page 8½" × 11" Bulletin illustrates and describes a protractor developed for those whose requirements demand extremely accurate layouts for use on their optical projectors and form grinders. Exactness of measurement is assured on the inspection screens of optical comparators. Engineers

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N-486 **Thermoregulators, etc.** 4-page 4" × 8" Bulletin 100 illustrates and describes a new line of "Mercuroplat" thermoregulators for adjustable temperature control of water, oil, air baths, ovens, etc.; permanent-setting thermostats for use where it is not necessary to change the operating temperature; sensitive relays for use with the thermoregulators and thermostats; and other items of special instruments and glassware. Washington Glass Laboratory and Instrument Co., 3224 Georgia Ave., N. W., Washington, D. C.

N-487 **Toolmaker Microscope.** 8-page 8½" × 11" Bulletin 155-64 illustrates and describes a large microscope equipped with a protractor head, a support column with adjustable tilt, and a mechanical stage permitting longitudinal, cross motion, and angular measurements. Also equipped with a removable cradle for holding certain types of work on the stage. The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

N-488 **Elements of Facsimile Communications.** 16-page 5½" × 8½" Booklet illustrates and describes a facsimile set for transmitting photos, messages and maps. The booklet was prepared for the benefit of those who are just becoming acquainted with the apparatus. For those acquainted with amplifier and basic communications theories, the elements of a commercial system are also described. Times Telephoto Equipment Inc., 299 W. 43 St., New York 18, N. Y.

N-489 **The Geiger-Mueller X-ray Spectrometer.** 8-page 8½" × 11" Booklet No. R1041 explains the history and construction details covering the instrument, along with circuits and data pertinent to correct usage. Practical applications, specimen preparations and methods of identification and other subjects are treated at length and illustrated with photos, drawings, tables and curves. North American Philips Co., 100 East 42nd St., New York 17, N. Y.

N-490 **Universal Impact Machines for Metals.** 4-page 8½" × 11" Bulletin 213 illustrates and gives specifications for the SI-1 Sonntag impact tester. The instrument is designed to meet ASTM specifications E-23-41T and has six possible ranges: 25 and 60 ft. lb., 50 and 120 ft. lb., and 100 and 240 ft. lb. The Baldwin Locomotive Works, Philadelphia 42, Pa.

N-491. **Optical Projection Comparators.** 4-page 8½" × 11" Bulletin, form SI illustrates and describes instruments for projecting an accurately magnified shadow for seeing and measuring "split thousandths." Examples of complete gaging are shown. Engineers Specialties Division, 980 Ellicott St., Buffalo 8, N. Y.

N-492 **Appliance Tester.** 2-page 8½" × 11" Bulletin illustrates and describes "Model 50" for trouble-shooting of open circuits, continuity, grounds and short circuits; for testing thermostats under actual working conditions; and for regulating heat on solder pots and soldering irons that have no thermostat control. Hanlan Company, 1419 West Jefferson Blvd., Los Angeles 7, Calif.

N-493 **Relays.** 4-page 8½" × 11" Folder, Form ECV illustrates and describes relays suited for most control purposes in industrial and communications work. All basic types are offered, together with wide variations for special applications. Electra Voice Corp., 5215-25 Ravenwood Ave., Chicago 40, Ill.

N-494 **Oxygen Indicator.** 4-page 8½" × 11" Bulletin DW-3 pictures and describes "Type C" for measuring oxygen content of inert and combustible atmospheres in chemical, metallurgical and petroleum industries. Principal uses are improving safety, controlling pipe line corrosion and achieving fuel economy. Mine Safety

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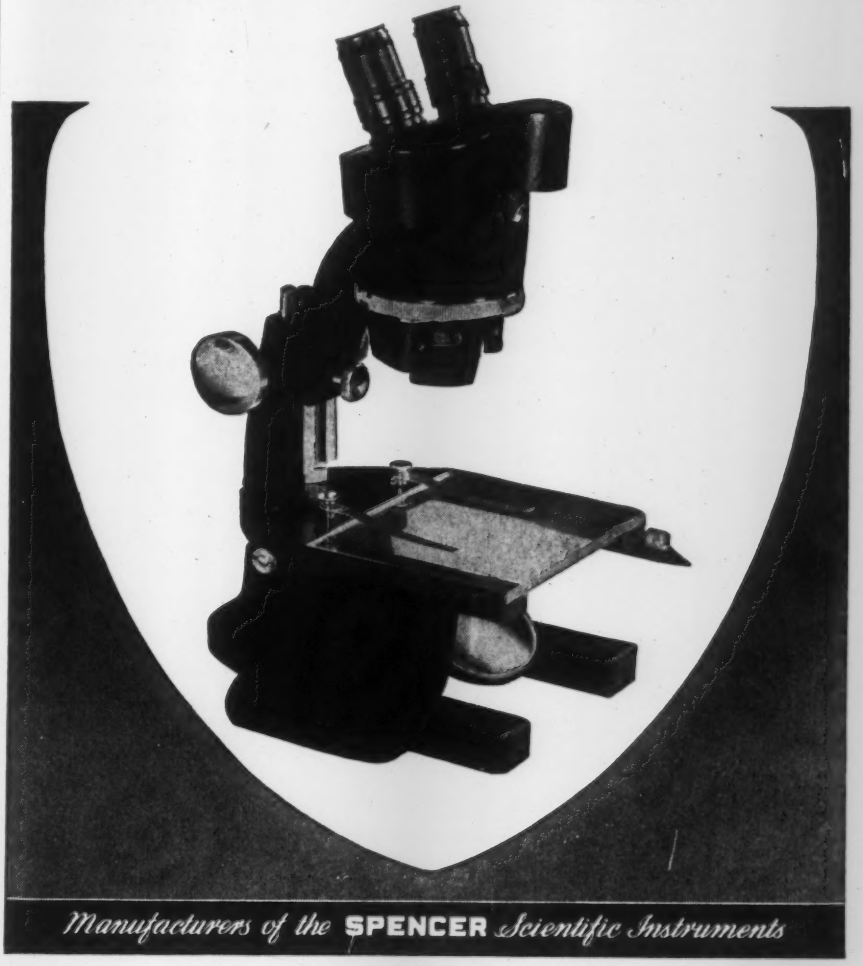

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